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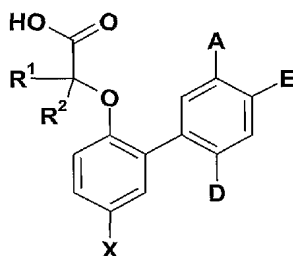
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(54) Title: BIPHENYLOXYACETIC ACID DERIVATIVES FOR THE TREATMENT OF RESPIRATORY DISEASE



(I)

(57) Abstract: The invention relates to substituted phenoxyacetic acids of formula (I), where the variables are as defined in claim 1, as useful pharmaceutical compounds for treating respiratory disorders, pharmaceutical compositions containing them, and processes for their preparation.

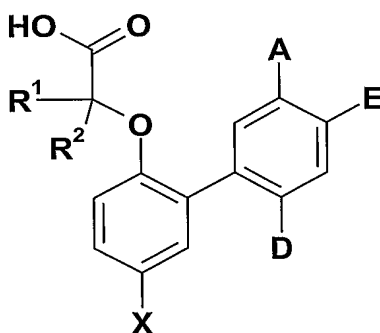
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# BIPHENYLOXYACETIC ACID DERIVATIVES FOR THE TREATMENT OF RESPIRATORY DISEASE

The present invention relates to substituted phenoxyacetic acids as useful pharmaceutical compounds for treating respiratory disorders, pharmaceutical compositions  
5 containing them, and processes for their preparation.

EPA 1 170 594 discloses methods for the identification of compounds useful for the treatment of disease states mediated by prostaglandin D<sub>2</sub>, a ligand for orphan receptor CRTH<sub>2</sub>. GB 1356834 discloses a series of compounds said to possess anti-inflammatory, analgesic and antipyretic activity. It has been found that certain phenoxyacetic acids are  
10 active at the CRTH<sub>2</sub> receptor, and as a consequence are expected to be potentially useful for the treatment of various respiratory diseases, including asthma and COPD.

In a first aspect the invention therefore provides a compound of formula (I) or a pharmaceutically acceptable salt thereof:



(I)

in which:

X is halogen, or C<sub>1-2</sub> alkyl which is substituted by one or more halogen atoms;

20 A and E are independently selected from halogen, SO<sub>2</sub>NR<sup>3</sup>R<sup>4</sup>, SO<sub>n</sub>R<sup>5</sup> (n=1 or 2), CONR<sup>3</sup>R<sup>4</sup>, or C<sub>1-3</sub> alkyl which can be optionally substituted by one or more halogen atoms;

D is hydrogen or fluorine;

R<sup>1</sup> and R<sup>2</sup> independently represent a hydrogen atom, or a C<sub>1-3</sub>alkyl group;

25 or

$R^1$  and  $R^2$  together can form a 3-8 membered ring optionally containing one or more atoms selected from O, S,  $NR^6$  and itself optionally substituted by one or more  $C_1$ - $C_3$  alkyl;

$R^3$  and  $R^4$  independently represent hydrogen,  $C_3$ - $C_7$  cycloalkyl or  $C_{1-6}$ alkyl, the latter two groups being optionally substituted by one or more substituents independently selected from halogen,  $C_3$ - $C_7$  cycloalkyl,  $OR^6$  and  $NR^7R^8$ ;  
or

$R^3$  and  $R^4$  together with the nitrogen atom to which they are attached can form a 3-8 membered saturated heterocyclic ring optionally containing one or more atoms selected from O,  $S(O)_n$  (where  $n = 0, 1$  or  $2$ ),  $NR^8$ , and itself optionally substituted by halogen or  $C_{1-3}$  alkyl;

10  $R^5$  is  $C_1$ - $C_6$  alkyl or  $C_{3-7}$  cycloalkyl, which may be optionally substituted by halogen atoms;

$R^6$  is hydrogen or  $C_1$ - $C_6$  alkyl;

$R^7$  and  $R^8$  independently represent hydrogen,  $C_{1-6}$  alkyl or  $C_{3-7}$  cycloalkyl

or

15  $R^7$  and  $R^8$  together with the nitrogen atom to which they are attached can form a 3-8 membered saturated heterocyclic ring as defined above for  $R^3$  and  $R^4$ .

In the context of the present specification, unless otherwise indicated, an alkyl group or an alkyl moiety in a substituent group may be linear or branched.

Heterocyclic rings as defined for  $R^3$  and  $R^4$  or  $R^7$  and  $R^8$  means saturated heterocycles, 20 examples include morpholine, azetidine, pyrrolidine, piperidine and piperazine.

Preferably X is trifluoromethyl, chloro or fluoro.

Preferably A and E independently represent trifluoromethyl,  $C_{1-3}$ alkyl, halogen,  $SOR^5$ ,  $SO_2R^5$ ,  $CONR^3R^4$ , or  $SO_2NR^3R^4$ . More preferably A and E independently represent trifluoromethyl, methyl, fluoro, chloro,  $SO_2Me$ ,  $SO_2Et$ ,  $SO_2iPr$ ,  $SO_2NR^3R^4$  or  $CONR^3R^4$ .

25 More preferably A is trifluoromethyl, methyl, fluoro or chloro.

More preferably E is  $SO_2Me$ ,  $SO_2Et$ ,  $SO_2iPr$ ,  $SO_2NR^3R^4$  where  $R^3$  and  $R^4$  together form a morpholine ring or E is  $CONR^3R^4$  where  $R^3$  and  $R^4$  together form a pyrrolidine, piperidine, azetidine or isoxazoline ring, each optionally substituted by halogen or  $C_1$ - $C_3$  alkyl, or E is  $CONR^3R^4$  where  $R^3$  and  $R^4$  independently represent hydrogen,  $C_3$ - $C_7$  cycloalkyl

30 or

$C_{1-6}$ alkyl. The alkyl groups may be linear or branched.

Most preferably E is SO<sub>2</sub>Me, SO<sub>2</sub>Et, SO<sub>2</sub>NR<sup>3</sup>R<sup>4</sup> where R<sup>3</sup> and R<sup>4</sup> together form a morpholine ring or E is CONR<sup>3</sup>R<sup>4</sup> where R<sup>3</sup> and R<sup>4</sup> together form a pyrrolidine, piperidine, azetidine or isoxazoline ring, each optionally substituted by fluoro or methyl, or E is CONR<sup>3</sup>R<sup>4</sup> where R<sup>3</sup> and R<sup>4</sup> independently represent hydrogen, C<sub>3</sub>-C<sub>7</sub> cycloalkyl or C<sub>3-6</sub> alkyl. The alkyl groups may be linear or branched.

Preferably R<sup>1</sup> and R<sup>2</sup> are independently hydrogen or C<sub>1-3</sub> alkyl, more preferably R<sup>1</sup> and R<sup>2</sup> are both hydrogen or one is hydrogen and the other is methyl.

Preferably D is hydrogen or fluorine, more preferably hydrogen.

Preferred substituents A, D, E, X, R<sup>1</sup> and R<sup>2</sup> are those exemplified herein.

Preferred compounds of the invention include:

(2*S*)-2-[[4'-(methylsulfonyl)-3',5-bis(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

[[3',5-Dichloro-4'-(methylsulfonyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid;

[[3',5-Dichloro-4'-(methylsulfinyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid;

(2*S*)-2-[[3',5-Dichloro-4'-(methylsulfonyl)[1,1'-biphenyl]-2-yl]oxy]propanoic acid;

(2*S*)-2-[4-chloro-2-[2,5-difluoro-4-(4-morpholinylsulfonyl)phenoxy]phenoxy]-propanoic acid;

[[3'-Fluoro-4'-[(1-methylethyl)sulfonyl]-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid;

[[5-Chloro-4'-(methylsulfonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

[[5-Fluoro-4'-(methylsulfonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

[[4'-(Ethylsulfonyl)-3',5-bis(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid;

(2*S*)-2-[[4'-(Ethylsulfonyl)-3',5-bis(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]propanoic acid;

[[5-Chloro-4'-(4-morpholinylsulfonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid;

(2*S*)-2-[[5-Chloro-4'-(4-morpholinylsulfonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]propanoic acid;

[[5-Chloro-4'-(1-pyrrolidinylcarbonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

(2*S*)-2-[[5-Chloro-4'-(1-pyrrolidinylcarbonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]propanoic acid;

[[5-Chloro-4'-(ethylsulfonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid;

- (2S)- 2-[[5-Chloro4'-(methylsulfonyl)-(3'-trifluoromethyl)-[1,1'-biphenyl]-2-yl]oxy]propanoic acid;
- (2S)- 2-[[5-Chloro-3'-fluoro-4'-(methylsulfonyl)[1,1'-biphenyl]-2-yl]oxy]propanoic acid;
- [[3',5-dichloro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;
- 5 [[3',5-dichloro-4'-(4-morpholinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;
- [[4'-(1-azetidiny carbonyl)-3',5-dichloro[1,1'-biphenyl]-2-yl]oxy]-acetic acid;
- [[3',5-dichloro-4'-[(2R,6S)-2,6-dimethyl-1-piperidinyl]carbonyl][1,1'-biphenyl]-2-yl]oxy]-acetic acid;
- [[3',5-dichloro-4'-(2-methyl-1-pyrrolidinyl)carbonyl][1,1'-biphenyl]-2-yl]oxy]-acetic acid;
- 10 [[3',5-dichloro-4'-(2-isoxazolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;
- [[5-chloro-3'-fluoro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;
- (2S)-2-[[5-chloro-3'-fluoro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;
- [[3'-methyl-4'-(1-piperidinylcarbonyl)-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;
- 15 acid;
- [[3'-methyl-4'-(1-pyrrolidinylcarbonyl)-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;
- (2S)-2-[[4'-[[bis(1-methylethyl)amino]carbonyl]-5-chloro-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;
- 20 (2S)-2-[[5-chloro-4'-[(ethylmethylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;
- (2S)-2-[[5-chloro-3'-fluoro-4'-[[methyl(1-methylethyl)amino]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid;
- (2S)-2-[[5-chloro-4'-[(diethylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;
- 25 acid;
- (2S)-2-[[5-chloro-4'-[(3,3-difluoro-1-pyrrolidinyl)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;
- (2S)-2-[[4'-[[[(1,1-dimethylethyl)amino]carbonyl]-3'-fluoro-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;
- 30 (2S)-2-[[5-chloro-3'-fluoro-4'-[[[(1-methylethyl)amino]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2S)-2-[[5-chloro-3'-fluoro-4'-[(2-methylpropyl)amino]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2S)-2-[[3'-fluoro-4'-(1-pyrrolidinylcarbonyl)-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

5 (2S)-2-[[3',5-dichloro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2S)-2-[[5-chloro-3'-methyl-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

[[5-chloro-3'-methyl-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

10 [[3'-fluoro-4'-(1-pyrrolidinylcarbonyl)-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

(2S)-2-[[3'-methyl-4'-(1-pyrrolidinylcarbonyl)-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

[[3',5-difluoro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

(2S)-2-[[3',5-difluoro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

15 (2S)-2-[[5-chloro-3'-fluoro-4'-[(2-methyl-1-pyrrolidinyl)carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2S)-2-[[5-chloro-3'-fluoro-4'-[[2S)-2-methyl-1-pyrrolidinyl]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

20 (2S)-2-[[5-chloro-3'-fluoro-4'-[(2R)-2-methyl-1-pyrrolidinyl]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2S)-2-[[4'-[(cyclopentylamino)carbonyl]-3'-fluoro-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2S)-2-[[3'-fluoro-4'-[(1-methylethyl)amino]carbonyl]-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

25 (2S)-2-[[4'-[(ethylamino)carbonyl]-3'-fluoro-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2S)-2-[[5-chloro-4'-[(1,1-dimethylethyl)amino]carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

30 (2S)-2-[[5-chloro-4'-[(cyclopentylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2S)-2-[[5-chloro-4'-[(cyclopropylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2*S*)-2-[[5-chloro-4'-[[[(1-ethylpropyl)amino]carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2*S*)-2-[[5-chloro-3'-fluoro-4'-[(methylamino)carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

5 (2*S*)-2-[[5-chloro-4'-[[[(1,1-dimethylethyl)amino]carbonyl]-3'-methyl[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

[[5-chloro-4'-[[[(1-ethylpropyl)amino]carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

[[5-chloro-3'-fluoro-4'-[(methylamino)carbonyl][1,1'-biphenyl]-2-yl]oxy]-acetic acid;

(2*S*)-2-[[5-chloro-4'-[(ethylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic  
10 acid;

(2*S*)-2-[[5-chloro-4'-[(cyclobutylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2*S*)-2-[[5-chloro-4'-[[[(1,1-dimethylpropyl)amino]carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

15 (2*S*)-2-[[5-chloro-3'-fluoro-4'-[[[(3-methylbutyl)amino]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

and pharmaceutically acceptable salts thereof.

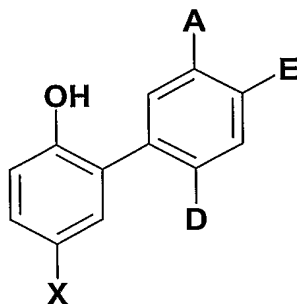
Certain compounds of formula (I) are capable of existing in stereoisomeric forms. It will be understood that the invention encompasses all geometric and optical isomers of the  
20 compounds of formula (I) and mixtures thereof including racemates. Tautomers and mixtures thereof also form an aspect of the present invention.

The compound of formula (I) above may be converted to a pharmaceutically acceptable salt or solvate thereof, preferably a basic addition salt such as sodium, potassium, calcium, aluminium, lithium, magnesium, zinc, benzathine, chlorprocaine, choline,  
25 diethanolamine, ethanolamine, ethyldiamine, meglumine, tromethamine or procaine, or an acid addition salt such as a hydrochloride, hydrobromide, phosphate, acetate, fumarate, maleate, tartrate, citrate, oxalate, methanesulphonate or *p*-toluenesulphonate.

It will be appreciated by those skilled in the art that in the processes of the present invention certain functional groups in the starting reagents or intermediate compound may  
30 need to be protected by protecting groups. Thus, the preparation of the compound of formula (I) may involve, at an appropriate stage, the removal of one or more protecting groups. The protection and deprotection of functional groups is fully described in 'Protective Groups in

Organic Chemistry', edited by J. W. F. McOmie, Plenum Press (1973), and 'Protective Groups in Organic Synthesis', 3rd edition, T. W. Greene & P. G. M. Wuts, Wiley-Interscience (1999).

Compounds of formula (I) can be prepared by reaction of a compound of formula (II):



(II)

in which X, A, D and E are as defined in formula (I) or are protected derivatives thereof, with  
10 a compound of formula (III):



Where  $\text{R}^1$  and  $\text{R}^2$  are as defined in formula (I) or are protected derivatives thereof,  $\text{R}^9$   
15 is H or  $\text{C}_1\text{-C}_{10}$  alkyl group and L is a leaving group, and optionally thereafter in any order:

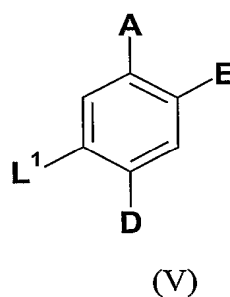
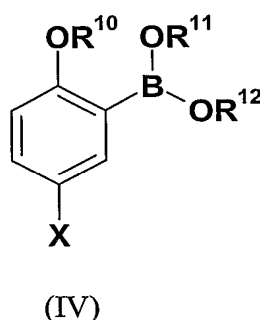
- removing any protecting group
- hydrolysing the ester group  $\text{R}^9$  to the corresponding acid
- oxidation of sulphides to sulfoxides or sulphones
- forming a pharmaceutically acceptable salt.

20 The reaction can be carried out in a suitable solvent such as acetonitrile or DMF using a base such as potassium carbonate or the like. Suitable groups  $\text{R}^9$  include  $\text{C}_{1-6}$  alkyl groups such as methyl, ethyl or tert-butyl. Suitable L is a leaving group such as tosylate or halo, in particular chlorine or bromine. L may also be hydroxy so that a Mitsunobu reaction may be performed with compound (II) using for example triphenylphosphine and diethyl  
25 azodicarboxylate.



Hydrolysis of the ester group  $R^9$  can be carried out using routine procedures, for example treatment of methyl and ethyl esters with aqueous sodium hydroxide, and treatment of tert-butyl esters with acids such as trifluoroacetic acid.

Compounds of formula (II) can be prepared by reaction of a compound of formula (IV) with a compound of formula (V) *via* a Suzuki coupling reaction followed by deprotection of  $R^{10}$ :

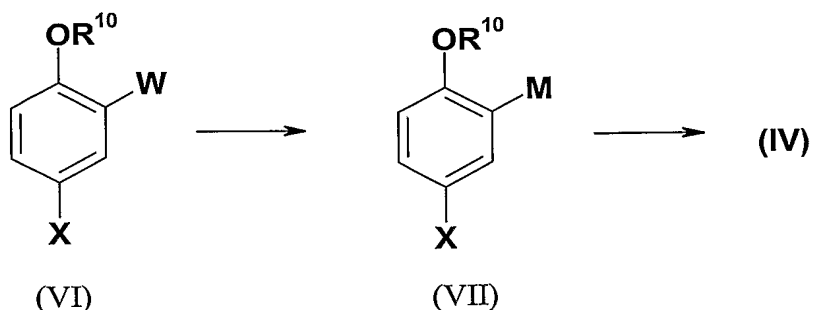


in which X, A, D and E are as defined in formula (I) or are protected derivatives thereof,  $R^{10}$  is H or a suitable protecting group, for example benzyl or methyl,  $L^1$  is iodide, bromide, chloride or triflate and  $R^{11}$  and  $R^{12}$  are H or  $C_1$ - $C_6$  alkyl groups or  $R^{11}$  and  $R^{12}$  together can form a 5 or 6 membered ring optionally substituted by one or more  $C_1$ - $C_3$  alkyl.

The reaction can be carried out in a suitable solvent such as dioxane using a palladium catalyst such as [1,1-bis(diphenylphosphino)ferrocene]dichloropalladium and a base such as cesium fluoride, preferably at elevated temperatures.

When  $R^{10}$  is a protecting group such as benzyl it can be removed using hydrogen with a suitable catalyst for example platinum or palladium on charcoal. If the group  $R^{10}$  is alkyl for example methyl, then it can be cleaved using borontribromide in a suitable solvent such as dichloromethane.

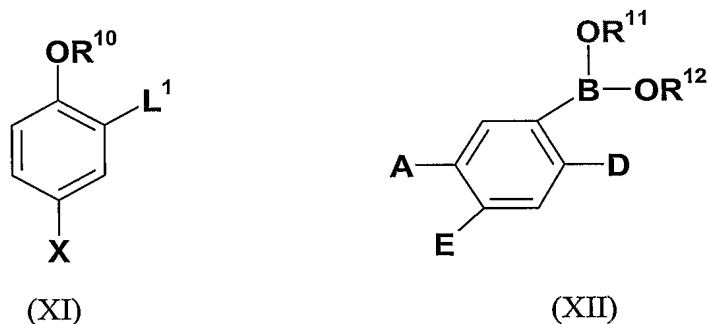
Some compounds of formula (IV) are commercially available. Certain compounds of formula (IV) can be prepared from a compound of formula (VI) by formation of an organometallic (VII) followed by reaction with a borate ester, as outlined in Scheme I.



Scheme I

5 in which X, is as defined in formula (I) or are protected derivatives thereof,  $R^{10}$  is as defined in formula (IV), W is hydrogen or halogen and M is a metal such as Na or Li. For example when  $R^{10}$  is benzyl and E is bromine, butyl lithium can be used to form the intermediate (VII) where  $M = \text{Li}$ . The reaction is performed at  $-78^\circ\text{C}$  in diethylether, then quenched with a borate ester such as trimethylborate.

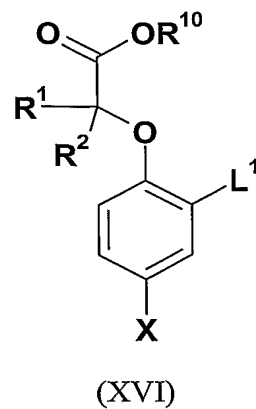
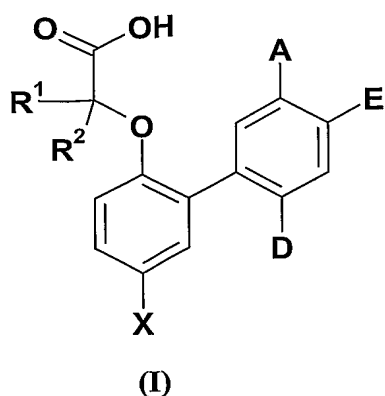
10 Compounds of formula (II) may also be prepared by reaction of a compound of formula (XI) with a compound of formula (XII) using Suzuki coupling methodology.



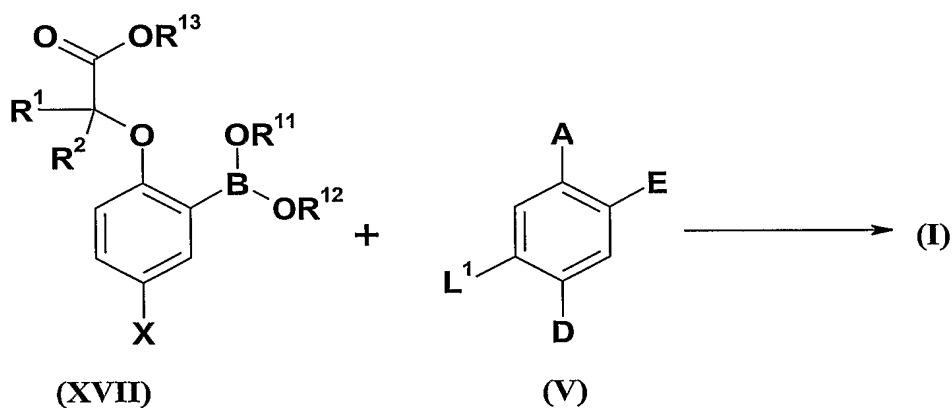
15 in which X, A, D, E,  $R^{10}$ ,  $L^1$ ,  $R^{11}$  and  $R^{12}$  are as defined above and compounds of formula (XI) and (XII) can be made using the same methodology as above.

The sequence of the steps above may be changed, for example a compound of formula (I) may be formed by the reaction of a compound of formula (XVI) with a compound of formula (XII) using a Suzuki coupling.

10

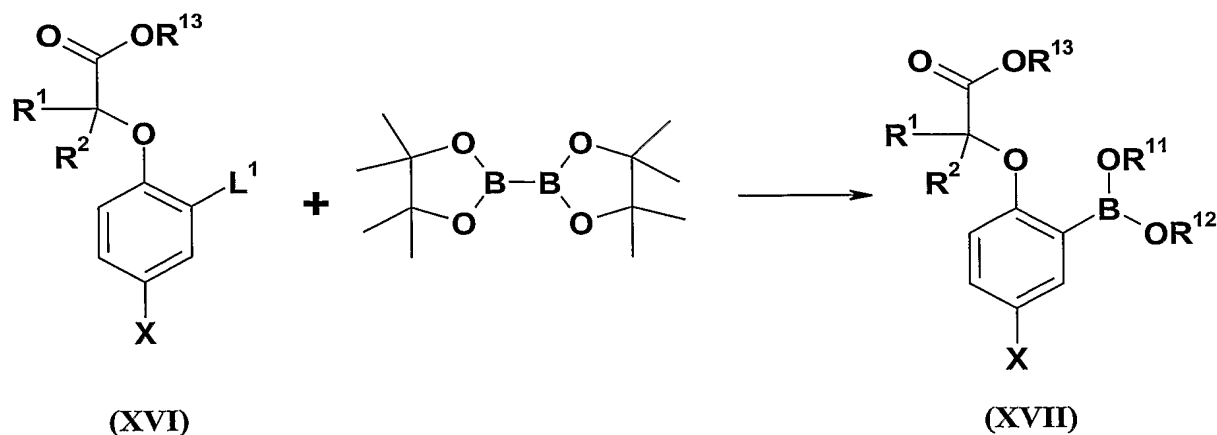


Or, compounds of formula (I) can be prepared by reaction of a compound of formula  
 5 (XVII) with a compound of formula (V):



10 Where the groups A, D, E, L<sup>1</sup>, X, R<sup>1</sup> and R<sup>2</sup> are as defined above or protected derivatives thereof. R<sup>13</sup> is hydrogen or C<sub>1</sub>-C<sub>6</sub> alkyl for example methyl ethyl or *tertiary* butyl. If R<sup>13</sup> is an ester group it is subsequently hydrolysed using either acidic or basic conditions, such as TFA or NaOH. Compounds of formula (XVII) can be prepared as outlined in  
 WO2004089885 or by reacting a compound of formula (XVII) with bis(pinacolato)diboron  
 15 using the Suzuki reaction.

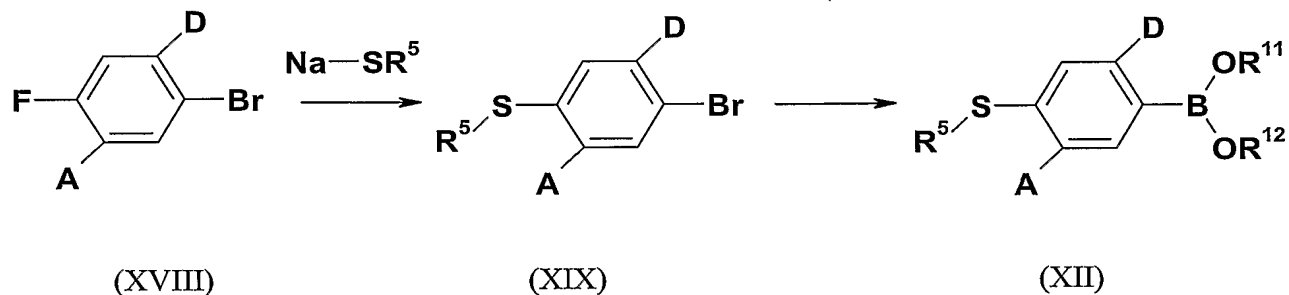
11



A compound of formula (XII) may be prepared by methods A or B.

5

#### Method A

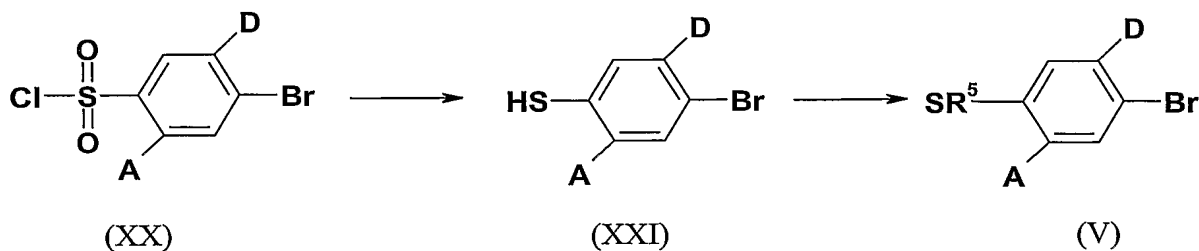


10

Compounds of formula (XII) where the group E is  $\text{SR}^5$  can be synthesised by displacing the Fluorine with  $\text{R}^5\text{SNa}$  in a suitable solvent such as DMF at  $50^\circ\text{C}$ . Compounds of formula (XIX) can be converted to the boronic acid using BuLi, then reacting with a borate ester as outlined previously. Alternatively the compounds of formula (XVII) can be prepared by a palladium catalysed coupling of compounds of formula (XIX) with a suitable boronic ester, for example bis(pinocolato)diboron.

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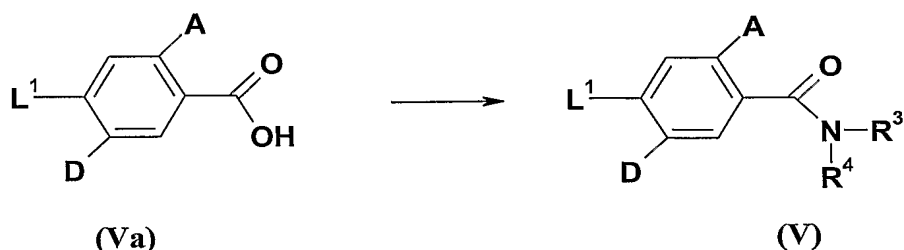
#### Method B



Compounds of formula (XIX) can also be prepared from compounds of formula (XX) where the chlorosulphonic acid is reduced to the thiol using triphenylphosphine, subsequently alkylated using an alkyl halide such as alkyl iodide or bromide.

5

Compounds of formula (V) where the group E is amide can be prepared by method C:



10 in which a compound of formula (Va) is converted to the acid chloride using a reagent such as oxalyl chloride and subsequently reacted with an amine in a suitable solvent such as dichloromethane. The groups A, D and L<sup>1</sup> are as defined for compounds of formula (V) or protected derivatives thereof.

Compounds of formula (Va) are commercially available or can be readily synthesised using  
 15 literature procedures by those skilled in the art.

Novel intermediates of the general formulae given above form a further aspect of the invention.

In a further aspect, the present invention provides the use of a compound of formula (I), a prodrug, pharmaceutically acceptable salt or solvate thereof for use in therapy.

20 The compounds of formula (I) have activity as pharmaceuticals, in particular as modulators of CRTh2 receptor activity, and may be used in the treatment (therapeutic or prophylactic) of conditions/diseases in human and non-human animals which are exacerbated or caused by excessive or unregulated production of PGD<sub>2</sub> and its metabolites. Examples of such conditions/diseases include:

- 25 1. respiratory tract: obstructive diseases of the airways including: asthma, including bronchial, allergic, intrinsic, extrinsic, exercise-induced, drug-induced (including aspirin and NSAID-induced) and dust-induced asthma, both intermittent and persistent and of all severities, and other causes of airway hyper-responsiveness; chronic obstructive pulmonary disease (COPD); bronchitis, including infectious and eosinophilic bronchitis; emphysema;

bronchiectasis; cystic fibrosis; sarcoidosis; farmer's lung and related diseases; hypersensitivity pneumonitis; lung fibrosis, including cryptogenic fibrosing alveolitis, idiopathic interstitial pneumonias, fibrosis complicating anti-neoplastic therapy and chronic infection, including tuberculosis and aspergillosis and other fungal infections; complications  
5 of lung transplantation; vasculitic and thrombotic disorders of the lung vasculature, and pulmonary hypertension; antitussive activity including treatment of chronic cough associated with inflammatory and secretory conditions of the airways, and iatrogenic cough; acute and chronic rhinitis including rhinitis medicamentosa, and vasomotor rhinitis; perennial and seasonal allergic rhinitis including rhinitis nervosa (hay fever); nasal polyposis; acute viral  
10 infection including the common cold, and infection due to respiratory syncytial virus, influenza, coronavirus (including SARS) and adenovirus;

2. bone and joints: arthritides associated with or including osteoarthritis/osteoarthrosis, both primary and secondary to, for example, congenital hip dysplasia; cervical and lumbar spondylitis, and low back and neck pain; rheumatoid arthritis and Still's disease; seronegative  
15 spondyloarthropathies including ankylosing spondylitis, psoriatic arthritis, reactive arthritis and undifferentiated spondarthropathy; septic arthritis and other infection-related arthropathies and bone disorders such as tuberculosis, including Potts' disease and Poncet's syndrome; acute and chronic crystal-induced synovitis including urate gout, calcium pyrophosphate deposition disease, and calcium apatite related tendon, bursal and synovial inflammation;  
20 Behcet's disease; primary and secondary Sjogren's syndrome; systemic sclerosis and limited scleroderma; systemic lupus erythematosus, mixed connective tissue disease, and undifferentiated connective tissue disease; inflammatory myopathies including dermatomyositis and polymyositis; polymyalgia rheumatica; juvenile arthritis including idiopathic inflammatory arthritides of whatever joint distribution and associated syndromes,  
25 and rheumatic fever and its systemic complications; vasculitides including giant cell arteritis, Takayasu's arteritis, Churg-Strauss syndrome, polyarteritis nodosa, microscopic polyarteritis, and vasculitides associated with viral infection, hypersensitivity reactions, cryoglobulins, and paraproteins; low back pain; Familial Mediterranean fever, Muckle-Wells syndrome, and Familial Hibernian Fever, Kikuchi disease; drug-induced arthralgias, tendonitides, and  
30 myopathies;

3. pain and connective tissue remodelling of musculoskeletal disorders due to injury [for example sports injury] or disease: arthritides (for example rheumatoid arthritis, osteoarthritis,

gout or crystal arthropathy), other joint disease (such as intervertebral disc degeneration or temporomandibular joint degeneration), bone remodelling disease (such as osteoporosis, Paget's disease or osteonecrosis), polychondritits, scleroderma, mixed connective tissue disorder, spondyloarthropathies or periodontal disease (such as periodontitis);

- 5 4. skin: psoriasis, atopic dermatitis, contact dermatitis or other eczematous dermatoses, and delayed-type hypersensitivity reactions; phyto- and photodermatitis; seborrhoeic dermatitis, dermatitis herpetiformis, lichen planus, lichen sclerosus et atrophica, pyoderma gangrenosum, skin sarcoid, discoid lupus erythematosus, pemphigus, pemphigoid, epidermolysis bullosa, urticaria, angioedema, vasculitides, toxic erythemas, cutaneous
  - 10 eosinophilias, alopecia areata, male-pattern baldness, Sweet's syndrome, Weber-Christian syndrome, erythema multiforme; cellulitis, both infective and non-infective; panniculitis; cutaneous lymphomas, non-melanoma skin cancer and other dysplastic lesions; drug-induced disorders including fixed drug eruptions;
  5. eyes: blepharitis; conjunctivitis, including perennial and vernal allergic conjunctivitis;
    - 15 iritis; anterior and posterior uveitis; choroiditis; autoimmune; degenerative or inflammatory disorders affecting the retina; ophthalmitis including sympathetic ophthalmitis; sarcoidosis; infections including viral, fungal, and bacterial;
    6. gastrointestinal tract: glossitis, gingivitis, periodontitis; oesophagitis, including reflux; eosinophilic gastro-enteritis, mastocytosis, Crohn's disease, colitis including ulcerative colitis,
      - 20 proctitis, pruritis ani; coeliac disease, irritable bowel syndrome, and food-related allergies which may have effects remote from the gut (for example migraine, rhinitis or eczema);
      7. abdominal: hepatitis, including autoimmune, alcoholic and viral; fibrosis and cirrhosis of the liver; cholecystitis; pancreatitis, both acute and chronic;
      8. genitourinary: nephritis including interstitial and glomerulonephritis; nephrotic
        - 25 syndrome; cystitis including acute and chronic (interstitial) cystitis and Hunner's ulcer; acute and chronic urethritis, prostatitis, epididymitis, oophoritis and salpingitis; vulvo-vaginitis; Peyronie's disease; erectile dysfunction (both male and female);
        9. allograft rejection: acute and chronic following, for example, transplantation of kidney, heart, liver, lung, bone marrow, skin or cornea or following blood transfusion; or
          - 30 chronic graft versus host disease;
          10. CNS: Alzheimer's disease and other dementing disorders including CJD and nvCJD; amyloidosis; multiple sclerosis and other demyelinating syndromes; cerebral atherosclerosis

and vasculitis; temporal arteritis; myasthenia gravis; acute and chronic pain (acute, intermittent or persistent, whether of central or peripheral origin) including visceral pain, headache, migraine, trigeminal neuralgia, atypical facial pain, joint and bone pain, pain arising from cancer and tumor invasion, neuropathic pain syndromes including diabetic, post-herpetic, and HIV-associated neuropathies; neurosarcoidosis; central and peripheral nervous system complications of malignant, infectious or autoimmune processes;

11. other auto-immune and allergic disorders including Hashimoto's thyroiditis, Graves' disease, Addison's disease, diabetes mellitus, idiopathic thrombocytopaenic purpura, eosinophilic fasciitis, hyper-IgE syndrome, antiphospholipid syndrome;

12. other disorders with an inflammatory or immunological component; including acquired immune deficiency syndrome (AIDS), leprosy, Sezary syndrome, and paraneoplastic syndromes;

13. cardiovascular: atherosclerosis, affecting the coronary and peripheral circulation; pericarditis; myocarditis, inflammatory and auto-immune cardiomyopathies including myocardial sarcoid; ischaemic reperfusion injuries; endocarditis, valvulitis, and aortitis including infective (for example syphilitic); vasculitides; disorders of the proximal and peripheral veins including phlebitis and thrombosis, including deep vein thrombosis and complications of varicose veins;

14. oncology: treatment of common cancers including prostate, breast, lung, ovarian, pancreatic, bowel and colon, stomach, skin and brain tumors and malignancies affecting the bone marrow (including the leukaemias) and lymphoproliferative systems, such as Hodgkin's and non-Hodgkin's lymphoma; including the prevention and treatment of metastatic disease and tumour recurrences, and paraneoplastic syndromes; and,

15. gastrointestinal tract: Coeliac disease, proctitis, eosinophilic gastro-enteritis, mastocytosis, Crohn's disease, ulcerative colitis, microscopic colitis, indeterminate colitis, irritable bowel disorder, irritable bowel syndrome, non-inflammatory diarrhea, food-related allergies which have effects remote from the gut, e.g., migraine, rhinitis and eczema.

16. Diseases associated with raised levels of PGD<sub>2</sub> or its metabolites.

Thus, the present invention provides a compound of formula (I), or a pharmaceutically-acceptable salt or solvate thereof, as hereinbefore defined for use in therapy.

Preferably the compounds of the invention are used to treat diseases in which the chemokine receptor belongs to the CRTh2 receptor subfamily.



Particular conditions which can be treated with the compounds of the invention are asthma, rhinitis and other diseases in which raised levels of  $\text{PGD}_2$  or its metabolites. It is preferred that the compounds of the invention are used to treat asthma.

In a further aspect, the present invention provides the use of a compound of formula (I), or a pharmaceutically acceptable salt or solvate thereof, as hereinbefore defined in the manufacture of a medicament for use in therapy.

In a further aspect, the present invention provides the use of a compound or formula (I), or a pharmaceutically acceptable salt or solvate thereof, as hereinbefore defined in the manufacture of a medicament for use in therapy in combination with drugs used to treat asthma and rhinitis (such as inhaled and oral steroids, inhaled  $\beta_2$ -receptor agonists and oral leukotriene receptor antagonists).

The invention further relates to combination therapies wherein a compound of the invention, or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition or formulation comprising a compound of the invention, is administered concurrently or sequentially or as a combined preparation with another therapeutic agent or agents, for the treatment of one or more of the conditions listed.

In particular, for the treatment of the inflammatory diseases such as (but not restricted to) rheumatoid arthritis, osteoarthritis, asthma, allergic rhinitis, chronic obstructive pulmonary disease (COPD), psoriasis, and inflammatory bowel disease, the compounds of the invention may be combined with agents listed below.

Non-steroidal anti-inflammatory agents (hereinafter NSAIDs) including non-selective cyclo-oxygenase COX-1 / COX-2 inhibitors whether applied topically or systemically (such as piroxicam, diclofenac, propionic acids such as naproxen, flurbiprofen, fenoprofen, ketoprofen and ibuprofen, fenamates such as mefenamic acid, indomethacin, sulindac, azapropazone, pyrazolones such as phenylbutazone, salicylates such as aspirin); selective COX-2 inhibitors (such as meloxicam, celecoxib, rofecoxib, valdecoxib, lumarocoxib, parecoxib and etoricoxib); cyclo-oxygenase inhibiting nitric oxide donors (CINODs); glucocorticosteroids (whether administered by topical, oral, intramuscular, intravenous, or intra-articular routes); methotrexate; leflunomide; hydroxychloroquine; d-penicillamine; auranofin or other parenteral or oral gold preparations; analgesics; diacerein; intra-articular therapies such as hyaluronic acid derivatives; and nutritional supplements such as glucosamine.

The present invention still further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, together with a cytokine or agonist or antagonist of cytokine function, (including agents which act on cytokine signalling pathways such as modulators of the SOCS system) including alpha-, beta-, and gamma-interferons; insulin-like growth factor type I (IGF-1); interleukins (IL) including IL1 to 17, and interleukin antagonists or inhibitors such as anakinra; tumour necrosis factor alpha (TNF- $\alpha$ ) inhibitors such as anti-TNF monoclonal antibodies (for example infliximab; adalimumab, and CDP-870) and TNF receptor antagonists including immunoglobulin molecules (such as etanercept) and low-molecular-weight agents such as pentoxifylline.

In addition the invention relates to a combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, with a monoclonal antibody targeting B-Lymphocytes (such as CD20 (rituximab), MRA-aIL16R and T-Lymphocytes, CTLA4-Ig, HuMax Il-15).

The present invention still further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, with a modulator of chemokine receptor function such as an antagonist of CCR1, CCR2, CCR2A, CCR2B, CCR3, CCR4, CCR5, CCR6, CCR7, CCR8, CCR9, CCR10 and CCR11 (for the C-C family); CXCR1, CXCR2, CXCR3, CXCR4 and CXCR5 (for the C-X-C family) and CX<sub>3</sub>CR1 for the C-X<sub>3</sub>-C family.

The present invention further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, with an inhibitor of matrix metalloprotease (MMPs), i.e., the stromelysins, the collagenases, and the gelatinases, as well as aggrecanase; especially collagenase-1 (MMP-1), collagenase-2 (MMP-8), collagenase-3 (MMP-13), stromelysin-1 (MMP-3), stromelysin-2 (MMP-10), and stromelysin-3 (MMP-11) and MMP-9 and MMP-12, including agents such as doxycycline.

The present invention still further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, and a leukotriene biosynthesis inhibitor, 5-lipoxygenase (5-LO) inhibitor or 5-lipoxygenase activating protein (FLAP) antagonist such as; zileuton; ABT-761; fenleuton; tepoxalin; Abbott-79175; Abbott-85761; a N-(5-substituted)-thiophene-2-alkylsulfonamide; 2,6-di-tert-butylphenolhydrazones; a methoxytetrahydropyrans such as Zeneca ZD-2138; the compound SB-210661; a pyridinyl-

substituted 2-cyanonaphthalene compound such as L-739,010; a 2-cyanoquinoline compound such as L-746,530; or an indole or quinoline compound such as MK-591, MK-886, and BAY x 1005.

The present invention further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, and a receptor antagonist for leukotrienes (LT) B<sub>4</sub>, LTC<sub>4</sub>, LTD<sub>4</sub>, and LTE<sub>4</sub>, selected from the group consisting of the phenothiazin-3-yls such as L-651,392; amidino compounds such as CGS-25019c; benzoxalamines such as ontazolast; benzenecarboximidamides such as BIIL 284/260; and compounds such as zafirlukast, ablukast, montelukast, pranlukast, verlukast (MK-679), RG-10 12525, Ro-245913, iralukast (CGP 45715A), and BAY x 7195.

The present invention still further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, and a phosphodiesterase (PDE) inhibitor such as a methylxanthanine including theophylline and aminophylline; a selective PDE isoenzyme inhibitor including a PDE4 inhibitor an inhibitor of the isoform PDE4D, or 15 an inhibitor of PDE5.

The present invention further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, and a histamine type 1 receptor antagonist such as cetirizine, loratadine, desloratadine, fexofenadine, acrivastine, terfenadine, astemizole, azelastine, levocabastine, chlorpheniramine, promethazine, cyclizine, or 20 mizolastine; applied orally, topically or parenterally.

The present invention still further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, and a proton pump inhibitor (such as omeprazole) or a gastroprotective histamine type 2 receptor antagonist.

The present invention further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, and an antagonist of the histamine 25 type 4 receptor.

The present invention still further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, and an alpha-1/alpha-2 adrenoceptor agonist vasoconstrictor sympathomimetic agent, such as propylhexedrine, phenylephrine, 30 phenylpropanolamine, ephedrine, pseudoephedrine, naphazoline hydrochloride, oxymetazoline hydrochloride, tetrahydrozoline hydrochloride, xylometazoline hydrochloride, tramazoline hydrochloride or ethylnorepinephrine hydrochloride.

The present invention further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, and an anticholinergic agents including muscarinic receptor (M1, M2, and M3) antagonist such as atropine, hyoscine, glycopyrrrolate, ipratropium bromide, tiotropium bromide, oxitropium bromide, pirfenidone  
5 or telencephalin.

The present invention still further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, and a beta-adrenoceptor agonist (including beta receptor subtypes 1-4) such as isoprenaline, salbutamol, formoterol, salmeterol, terbutaline, orciprenaline, bitolterol mesylate, or pirbuterol, or a chiral enantiomer  
10 thereof.

The present invention further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, and a chromone, such as sodium cromoglycate or nedocromil sodium.

The present invention still further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, with a glucocorticoid, such as flunisolide, triamcinolone acetonide, beclomethasone dipropionate, budesonide, fluticasone propionate, ciclesonide or mometasone furoate.  
15

The present invention further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, with an agent that modulates a  
20 nuclear hormone receptor such as PPARs.

The present invention still further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, together with an immunoglobulin (Ig) or Ig preparation or an antagonist or antibody modulating Ig function such as anti-IgE (for example omalizumab).

25 The present invention further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, and another systemic or topically-applied anti-inflammatory agent, such as thalidomide or a derivative thereof, a retinoid, dithranol or calcipotriol.

The present invention still further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, and combinations of aminosaliclates  
30 and sulfapyridine such as sulfasalazine, mesalazine, balsalazide, and olsalazine; and immunomodulatory agents such as the thiopurines, and corticosteroids such as budesonide.

The present invention further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, together with an antibacterial agent such as a penicillin derivative, a tetracycline, a macrolide, a beta-lactam, a fluoroquinolone, metronidazole, an inhaled aminoglycoside; an antiviral agent including acyclovir, famciclovir, valaciclovir, ganciclovir, cidofovir, amantadine, rimantadine, ribavirin, zanamavir and oseltamavir; a protease inhibitor such as indinavir, nelfinavir, ritonavir, and saquinavir; a nucleoside reverse transcriptase inhibitor such as didanosine, lamivudine, stavudine, zalcitabine or zidovudine; or a non-nucleoside reverse transcriptase inhibitor such as nevirapine or efavirenz.

10 The present invention still further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, and a cardiovascular agent such as a calcium channel blocker, a beta-adrenoceptor blocker, an angiotensin-converting enzyme (ACE) inhibitor, an angiotensin-2 receptor antagonist; a lipid lowering agent such as a statin or a fibrate; a modulator of blood cell morphology such as pentoxifylline; thrombolytic, or an  
15 anticoagulant such as a platelet aggregation inhibitor.

The present invention further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, and a CNS agent such as an antidepressant (such as sertraline), an anti-Parkinsonian drug (such as deprenyl, L-dopa, ropinirole, pramipexole, a MAOB inhibitor such as selegine and rasagiline, a comP inhibitor  
20 such as tasmar, an A-2 inhibitor, a dopamine reuptake inhibitor, an NMDA antagonist, a nicotine agonist, a dopamine agonist or an inhibitor of neuronal nitric oxide synthase), or an anti-Alzheimer's drug such as donepezil, rivastigmine, tacrine, a COX-2 inhibitor, propentofylline or metrifonate.

The present invention still further relates to the combination of a compound of the  
25 invention, or a pharmaceutically acceptable salt thereof, and an agent for the treatment of acute or chronic pain, such as a centrally or peripherally-acting analgesic (for example an opioid or derivative thereof), carbamazepine, phenytoin, sodium valproate, amitriptyline or other anti-depressant agent-s, paracetamol, or a non-steroidal anti-inflammatory agent.

The present invention further relates to the combination of a compound of the  
30 invention, or a pharmaceutically acceptable salt thereof, together with a parenterally or topically-applied (including inhaled) local anaesthetic agent such as lignocaine or a derivative thereof.

A compound of the present invention, or a pharmaceutically acceptable salt thereof, can also be used in combination with an anti-osteoporosis agent including a hormonal agent such as raloxifene, or a biphosphonate such as alendronate.

The present invention still further relates to the combination of a compound of the invention, or a pharmaceutically acceptable salt thereof, together with a: (i) tryptase inhibitor; (ii) platelet activating factor (PAF) antagonist; (iii) interleukin converting enzyme (ICE) inhibitor; (iv) IMPDH inhibitor; (v) adhesion molecule inhibitors including VLA-4 antagonist; (vi) cathepsin; (vii) kinase inhibitor such as an inhibitor of tyrosine kinase (such as Btk, Itk, Jak3 or MAP, for example Gefitinib or Imatinib mesylate), a serine / threonine kinase (such as an inhibitor of a MAP kinase such as p38, JNK, protein kinase A, B or C, or IKK), or a kinase involved in cell cycle regulation (such as a cyclin dependent kinase); (viii) glucose-6 phosphate dehydrogenase inhibitor; (ix) kinin-B.sub1. - or B.sub2. -receptor antagonist; (x) anti-gout agent, for example colchicine; (xi) xanthine oxidase inhibitor, for example allopurinol; (xii) uricosuric agent, for example probenecid, sulfinpyrazone or benzbromarone; (xiii) growth hormone secretagogue; (xiv) transforming growth factor (TGF $\beta$ ); (xv) platelet-derived growth factor (PDGF); (xvi) fibroblast growth factor for example basic fibroblast growth factor (bFGF); (xvii) granulocyte macrophage colony stimulating factor (GM-CSF); (xviii) capsaicin cream; (xix) tachykinin NK.sub1. or NK.sub3. receptor antagonist such as NKP-608C, SB-233412 (talnetant) or D-4418; (xx) elastase inhibitor such as UT-77 or ZD-0892; (xxi) TNF-alpha converting enzyme inhibitor (TACE); (xxii) induced nitric oxide synthase (iNOS) inhibitor; (xxiii) chemoattractant receptor-homologous molecule expressed on TH2 cells, (such as a CRTH2 antagonist); (xxiv) inhibitor of P38; (xxv) agent modulating the function of Toll-like receptors (TLR), (xxvi) agent modulating the activity of purinergic receptors such as P2X7; or (xxvii) inhibitor of transcription factor activation such as NFkB, API, or STATS.

A compound of the invention, or a pharmaceutically acceptable salt thereof, can also be used in combination with an existing therapeutic agent for the treatment of cancer, for example suitable agents include:

(i) an antiproliferative/antineoplastic drug or a combination thereof, as used in medical oncology, such as an alkylating agent (for example cis-platin, carboplatin, cyclophosphamide, nitrogen mustard, melphalan, chlorambucil, busulphan or a nitrosourea); an antimetabolite (for example an antifolate such as a fluoropyrimidine like 5-fluorouracil or tegafur,

- raltitrexed, methotrexate, cytosine arabinoside, hydroxyurea, gemcitabine or paclitaxel); an antitumour antibiotic (for example an anthracycline such as adriamycin, bleomycin, doxorubicin, daunomycin, epirubicin, idarubicin, mitomycin-C, dactinomycin or mithramycin); an antimitotic agent (for example a vinca alkaloid such as vincristine, vinblastine, vindesine or vinorelbine, or a taxoid such as taxol or taxotere); or a topoisomerase inhibitor (for example an epipodophyllotoxin such as etoposide, teniposide, amsacrine, topotecan or a camptothecin);
- (ii) a cytostatic agent such as an antioestrogen (for example tamoxifen, toremifene, raloxifene, droloxifene or idoxifene), an oestrogen receptor down regulator (for example fulvestrant), an antiandrogen (for example bicalutamide, flutamide, nilutamide or cyproterone acetate), a LHRH antagonist or LHRH agonist (for example goserelin, leuporelin or buserelin), a progestogen (for example megestrol acetate), an aromatase inhibitor (for example as anastrozole, letrozole, vorazole or exemestane) or an inhibitor of  $5\alpha$ -reductase such as finasteride;
- (iii) an agent which inhibits cancer cell invasion (for example a metalloproteinase inhibitor like marimastat or an inhibitor of urokinase plasminogen activator receptor function);
- (iv) an inhibitor of growth factor function, for example: a growth factor antibody (for example the anti-erbB2 antibody trastuzumab, or the anti-erbB1 antibody cetuximab [C225]), a farnesyl transferase inhibitor, a tyrosine kinase inhibitor or a serine/threonine kinase inhibitor, an inhibitor of the epidermal growth factor family (for example an EGFR family tyrosine kinase inhibitor such as N-(3-chloro-4-fluorophenyl)-7-methoxy-6-(3-morpholinopropoxy)quinazolin-4-amine (gefitinib, AZD1839), N-(3-ethynylphenyl)-6,7-bis(2-methoxyethoxy)quinazolin-4-amine (erlotinib, OSI-774) or 6-acrylamido-N-(3-chloro-4-fluorophenyl)-7-(3-morpholinopropoxy)quinazolin-4-amine (CI 1033)), an inhibitor of the platelet-derived growth factor family, or an inhibitor of the hepatocyte growth factor family;
- (v) an antiangiogenic agent such as one which inhibits the effects of vascular endothelial growth factor (for example the anti-vascular endothelial cell growth factor antibody bevacizumab, a compound disclosed in WO 97/22596, WO 97/30035, WO 97/32856 or WO 98/13354), or a compound that works by another mechanism (for example linomide, an inhibitor of integrin  $\alpha v \beta 3$  function or an angiostatin);
- (vi) a vascular damaging agent such as combretastatin A4, or a compound disclosed in WO 99/02166, WO 00/40529, WO 00/41669, WO 01/92224, WO 02/04434 or WO 02/08213;

(vii) an agent used in antisense therapy, for example one directed to one of the targets listed above, such as ISIS 2503, an anti-ras antisense;

(viii) an agent used in a gene therapy approach, for example approaches to replace aberrant genes such as aberrant p53 or aberrant BRCA1 or BRCA2, GDEPT (gene-directed enzyme pro-drug therapy) approaches such as those using cytosine deaminase, thymidine kinase or a bacterial nitroreductase enzyme and approaches to increase patient tolerance to chemotherapy or radiotherapy such as multi-drug resistance gene therapy; or

(ix) an agent used in an immunotherapeutic approach, for example ex-vivo and in-vivo approaches to increase the immunogenicity of patient tumour cells, such as transfection with cytokines such as interleukin 2, interleukin 4 or granulocyte-macrophage colony stimulating factor, approaches to decrease T-cell anergy, approaches using transfected immune cells such as cytokine-transfected dendritic cells, approaches using cytokine-transfected tumour cell lines and approaches using anti-idiotypic antibodies.

In a still further aspect, the present invention provides the use of a compound of formula (I), or a pharmaceutically acceptable salt or solvate thereof, as hereinbefore defined in the manufacture of a medicament for the treatment of human diseases or conditions in which modulation of CRTh2 receptor activity is beneficial.

In the context of the present specification, the term "therapy" also includes "prophylaxis" unless there are specific indications to the contrary. The terms "therapeutic" and "therapeutically" should be construed accordingly.

The invention still further provides a method of treating diseases mediated by PGD2 or its metabolites wherein the prostanoid binds to its receptor (especially CRTh2) receptor, which comprises administering to a patient a therapeutically effective amount of a compound of formula (I), or a pharmaceutically acceptable salt, solvate or prodrug thereof, as hereinbefore defined.

The invention also provides a method of treating an inflammatory disease, especially psoriasis, in a patient suffering from, or at risk of, said disease, which comprises administering to the patient a therapeutically effective amount of a compound of formula (I), or a pharmaceutically acceptable salt or solvate thereof, as hereinbefore defined.

For the above-mentioned therapeutic uses the dosage administered will, of course, vary with the compound employed, the mode of administration, the treatment desired and the disorder indicated.



For the above-mentioned therapeutic uses the dosage administered will, of course, vary with the compound employed, the mode of administration, the treatment desired and the disorder indicated.

The compound of formula (I), prodrugs and pharmaceutically acceptable salts and  
5 solvates thereof may be used on their own but will generally be administered in the form of a pharmaceutical composition in which the formula (I) compound/salt/solvate (active ingredient) is in association with a pharmaceutically acceptable adjuvant, diluent or carrier. Depending on the mode of administration, the pharmaceutical composition will preferably comprise from 0.05 to 99 %w (per cent by weight), more preferably from 0.05 to 80 %w, still  
10 more preferably from 0.10 to 70 %w, and even more preferably from 0.10 to 50 %w, of active ingredient, all percentages by weight being based on total composition.

The present invention also provides a pharmaceutical composition comprising a compound of formula (I), or a pharmaceutically acceptable salt or solvate thereof, as herein before defined, in association with a pharmaceutically acceptable adjuvant, diluent or carrier.

15 The pharmaceutical compositions may be administered topically (e.g. to the lung and/or airways or to the skin) in the form of solutions, suspensions, heptafluoroalkane aerosols and dry powder formulations; or systemically, e.g. by oral administration in the form of tablets, capsules, syrups, powders or granules, or by parenteral administration in the form of solutions or suspensions, or by subcutaneous administration or by rectal administration in  
20 the form of suppositories or transdermally. Preferably the compound of the invention is administered orally.

The invention will now be illustrated by the following non-limiting examples in which, unless stated otherwise:

(i) when given,  $^1\text{H}$  NMR data is quoted in the form of delta values for major  
25 diagnostic protons, given in parts per million (ppm) relative to tetramethylsilane (TMS) as an internal standard;

(ii) mass spectra (MS): generally only ions which indicate the parent mass are reported, and unless otherwise stated the mass ion quoted is the positive mass ion -  $(\text{M}+\text{H})^+$ ;

(iii) the title compounds of the examples and methods were named using the  
30 ACD/name and ACD/name batch (version 6.0) from Advanced Chemical Development Inc, Canada;

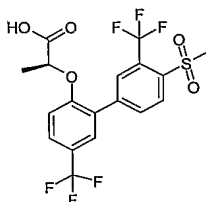
(iv) unless stated otherwise, reverse phase HPLC was conducted using a Symmetry,

NovaPak or Ex-Terra reverse phase silica column;

(v) solvents were dried with  $\text{MgSO}_4$  or  $\text{Na}_2\text{SO}_4$

(vi) the following abbreviations are used:

5	EtOAc	Ethylacetate
	Ether	diethyl ether
	DCM	Dichloromethane
	HCl	Hydrochloric acid
	NaOH	Sodium hydroxide
10	NMP	N-methylpyrrolidine
	DMF	N,N-dimethylformamide
	THF	tetrahydrofuran
	mcpba	3-chloroperoxybenzoic acid (Aldrich 77% max)
		$\text{Pd}(\text{dppf})\text{Cl}_2$ [1,1'-
15		Bis(diphenylphosphino)ferrocene]dichloropalladium(II), complex with
		dichloromethane
	RT	room temperature

**Example 1****(2S)-2-[[4'-(methylsulfonyl)-3',5-bis(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid****a) 4-bromo-1-(methylthio)-2-(trifluoromethyl)-benzene**

A mixture of sodium thiomethoxide (317 mg) and 5-bromo-2-fluorobenzotrifluoride (1.0 g) in DMF (4 ml) was heated at 50 °C for 1 h then poured into water and extracted with isohexane. The organics were washed with brine, dried and concentrated *in vacuo* to give the sub-title compound (762 mg).

<sup>1</sup>H NMR DMSO-d<sub>6</sub>: δ 7.74 (1H, d) 7.59 (1H, dd) ; 7.22 (1H, d) ; 2.51 (3H, s)

**b) [4-(methylthio)-3-(trifluoromethyl)phenyl]-boronic acid**

n-BuLi (2.7 ml, 2.5M in hexane) was added dropwise to the product of step a) and tri-isopropyl borate (1.6ml) in THF at -78 °C. Stirred for 5 min, then quenched with 2M HCl (50ml) and extracted with diethyl ether (50 ml). The organic layer was washed with water, brine, dried (Na<sub>2</sub>SO<sub>4</sub>) and evaporated *in vacuo*. The resulting solid was triturated with isohexane (100 ml), filtered and dried to give the product (0.83 g). NMR indicated a 2:1 mixture of product, monomer and trimer of boronic acid.

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 8.03 (1H, d), 7.51 (1H, dd), 6.7 (1H, d), 4.71 (1H, q), 1.69 (3H, d) and 1.43 (9H, s).

**c) 4,4,5,5-tetramethyl-2-[4-(methylthio)-3-(trifluoromethyl)phenyl]-1,3,2-dioxaborolane**

The product of step b) (0.25 g) was heated in dioxan (2 ml) with pinacol (2 equiv) for 3 h. The solution was treated with diethyl ether and water. The organic layer was separated, washed with brine, dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated *in vacuo*. Yield 85 mg.

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 8.03 (1H, d), 7.86 (1H, d), 7.31 (1H, d), 2.53 (3H, s) and 1.35 (12H, s).

**d) 2-iodo-4-(trifluoromethyl)-phenol**

4-(trifluoromethyl)-phenol (8g) in anhydrous DMF (80 ml) was cooled to 0 °C. NaI (9.06 g) and chloroamine-T (16.1 g) was added portionwise and stirred at room temperature overnight. Then diluted with 2M HCl and extracted with ethylacetate. The organic phase  
5 was washed with sodium thiosulfate solution, dried (MgSO<sub>4</sub>) and concentrated in vacuo. The residue was purified by chromatography (silica, eluting with isohexane:ethyl acetate) to give the sub-title compound as a yellow oil (13 g).

MS: APCI (-ve): 287 (M-H)

**e) 1,1-Dimethylethyl (2S)-2-[2-iodo-4-(trifluoromethyl)phenoxy]propanoate**

DIAD (2.9 ml) was added to the product of step e) (3.5 g), triphenyl phosphine (3.87 g) and tert-butyl (R)-(+)-lactate (1.96 g) in THF (35 ml) at 0°C and stirred for 18 h. The solvent was evaporated *in vacuo* and the residue purified by flash column chromatography eluting with petroleum ether:dichloromethane (4:1) to give the product as a colourless oil.

15 Yield\*\*

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 8.03 (1H, d), 7.51 (1H, dd), 6.7 (1H, d), 4.71 (1H, q), 1.69 (3H, d) and 1.43 (9H, s).

**f) 1,1-Dimethylethyl (2S)-2-[[4'-(methylthio)-3',5-bis(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy propanoate**

The products of step e) (0.3 g), the product of step c) (230 mg), sodium carbonate (170 mg), Pd(dppf)Cl<sub>2</sub> (50 mg), dioxan (10 ml) and methanol (1 ml) were heated at 90 °C for 24 h, then concentrated *in vacuo*. The residue was purified by flash column chromatography eluting with ethyl acetate:isohexane (2:8) to give the product (0.35 g), which was used  
25 directly without further characterisation.

**g) (2S)-2-[[4'-(methylthio)-3',5-bis(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

The product of step f) (0.34 g) in dichloromethane (6 ml) and TFA (3 ml) was stirred  
30 for 2 h at room temperature, then concentrated *in vacuo*. The residue was diluted with dichloromethane, washed with water, dried (MgSO<sub>4</sub>) then concentrated *in vacuo*. The residue was then dissolved in acetonitrile (10 ml) and water (10 ml) and treated with oxone (0.6 g).

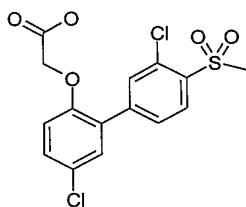
The reaction mixture was stirred for 2 h, further oxone (0.6 g) was added and the reaction stirred for 2 days. The solution was washed with dichloromethane (x 3). The combined extracts were dried (MgSO<sub>4</sub>) then concentrated *in vacuo*. Further purified by reverse phase HPLC, then trituration with dichloromethane and isoheaxne to give the title compound as a white solid (100 mg).

MS: APCI (-ve): 455 (M-H)

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 8.49 (1H, s), 8.31 (1H, d), 8.12 (1H, d), 7.84-7.76 (2H, m), 7.23 (1H, d), 5.13 (1H, q) and 1.46 (3H, d).

## Example 2

### [[3',5-Dichloro-4'-(methanesulfonyl)[1,1'-biphenyl]-2-yl]oxy]acetic Acid



#### a) 1,1-Dimethylethyl (4-chloro-2-iodophenoxy)acetate

A mixture of 5-chloro-2-iodophenol (4.75 g), 1,1-dimethylethyl bromoacetate (3.05 ml) and potassium carbonate (2.58 g) in acetonitrile (20 ml) was heated under reflux for 2 h. Water was added and the mixture was extracted with ether (three times). The organic extracts were dried (MgSO<sub>4</sub>), evaporated and purified by chromatography (silica, petrol – ether as eluent) to give the sub-title compound (6.88 g).

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 7.77 (1H, d), 7.45 (1H, dd), 6.61 (1H, d), 4.55 (2H, s), 1.48 (9H, s).

#### b) 4-Bromo-2-chloro-1-(methylthio) benzene

A mixture of 4-bromo-2-chloro-1-fluorobenzene (8.04 g) and sodium methylthiolate (3.05 g) in DMF (25 ml) was heated at 50 °C for 2.5 h. Water was added and the mixture was extracted with ether (three times). The organic extracts were washed with water (twice), dried (MgSO<sub>4</sub>), and evaporated to give the sub-title compound (8.93 g).

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 7.54 (1H, d), 7.34 (1H, dd), 7.02 (1H, dd), 2.47 (3H, s).

**c) [3-Chloro-4-(methylthio)phenyl] boronic acid**

Butyl lithium (15 ml, 1.9M in hexanes) was added over 40 min to a solution of the product from step b) (6.82 g) and triisopropylborate (8.0 ml) in THF (30 ml) at -78 °C and stirred for a further 1 h. 2M HCl (20 ml) was added, the mixture was warmed to 20 °C and  
5 extracted with ether (three times). The organic extracts were dried (MgSO<sub>4</sub>), evaporated and purified by chromatography (silica, petrol – ether as eluent) to give the sub-title compound (1.82 g).

MS: ESI (-ve): 201 [M-H]<sup>-</sup> 100%

**10 d) 1,1-Dimethylethyl [[3',5-dichloro-4'-(methylsulfonyl)[1,1'-biphenyl]-2-yl]oxy]acetate**

A mixture of the product of step a) (390 mg) and the product of step c) (239 mg), sodium carbonate (220 mg) and Pd(dppf)Cl<sub>2</sub> (74 mg) in dioxan (5 ml) and methanol (3 ml) was heated at 100 °C for 24 h, then concentrated *in vacuo* and dissolved in acetone (10 ml). A solution of oxone (2.0 g) in water and aq K<sub>2</sub>CO<sub>3</sub> (to keep the mixture at *ca.* pH 8) were  
15 added and stirred for 2 days. The mixture was extracted with ether (three times) and the organic extracts were dried (MgSO<sub>4</sub>), evaporated and purified by chromatography (silica, petrol – ether as eluent) to give the sub-title compound (73 mg).

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 8.18 (1H, d), 7.80 (1H, d), 7.70 (1H, dd), 7.34-7.31 (2H, m), 6.79 (1H, d), 4.54 (2H, s), 3.30 (3H, s), 1.47 (9H, s).

20 Further elution with ether gave 1,1-dimethylethyl [[3',5-dichloro-4'-(methylsulfinyl)[1,1'-biphenyl]-2-yl]oxy]acetate (35 mg)

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 7.99 (1H, d), 7.82 (1H, d), 7.66 (1H, dd), 7.35-7.28 (2H, m), 6.79 (1H, d), 4.53 (2H, s), 2.87 (2H, s), 1.47 (9H, s).

**25 e) [[3',5-Dichloro-4'-(methylsulfonyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid**

A solution of the product from step d) (73 mg) in TFA (3 ml) was stirred for 2 h. The solvent was removed *in vacuo*, water was added and the mixture was extracted with dichloromethane (three times). The organic extracts were dried (MgSO<sub>4</sub>), evaporated and triturated with ether to give the title compound (46 mg) as a white solid. M.p. 140-2 °C.

30 MS: ESI (+ve): 393 [M+NH<sub>4</sub>]<sup>+</sup> 100%

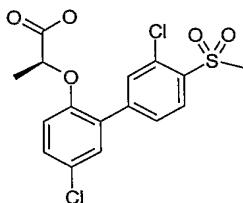
<sup>1</sup>H NMR DMSO-d<sub>6</sub>: δ 8.06 (1H, d), 8.02 (1H, d), 7.83 (1H, dd), 7.51 (1H, d), 7.46 (1H, dd), 7.13 (1H, d), 4.81 (3H, s), 3.41 (3H, s).

**Example 3****[[3',5-Dichloro-4'-(methylsulfinyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid**

A solution of the more polar product from Example 2 step d) (35 mg) in TFA (2 ml) was stirred for 24 h. The solvent was removed *in vacuo*, the mixture was azeotroped with toluene and purified by chromatography (silica, CH<sub>2</sub>Cl<sub>2</sub>-MeOH-AcOH as eluent) to give the title compound (22 mg) as a white solid.

MS: ESI (+ve): 359 [M+H]<sup>+</sup> 100%

<sup>1</sup>H NMR DMSO-d<sub>6</sub>: δ 7.86 (3H, s), 7.47 (1H, d), 7.43 (1H, dd), 7.11 (1H, d), 4.80 (2H, s), 2.85 (3H, s).

**Example 4****(2S)-2-[[3',5-Dichloro-4'-(methylsulfonyl)[1,1'-biphenyl]-2-yl]oxy]propanoic acid**

**a) 1,1-Dimethylethyl (2S)-2-(4-chloro-2-iodophenoxy)propanoate**

DIAD (1.64 ml) was added to a solution of 5-chloro-2-iodophenol 1.76 g), triphenyl phosphine (2.17 g) and tert butyl (R) lactate (1.02 g) in THF (8 ml) at 0 °C and stirred at 20 °C for 18 h. The solvent was removed *in vacuo* and the residue purified by (silica, petrol – ether as eluent) to give the sub-title compound (2.01 g).

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 7.76 (1H, d), 7.21 (1H, dd), 6.61 (1H, d), 4.61 (1H, q), 1.65 (3H, d), 1.42 (9H, s).

**b) 1,1-Dimethylethyl (2S)-2-[[3',5-dichloro-4'-(methylsulfonyl)[1,1'-biphenyl]-2-yl]oxy]propanoate**

A mixture of the product of step a) (412 mg) and the product of Example 2 step c) (246 mg), palladium acetate (22 mg), tris*ortho*toluenephosphine (49 mg) and sodium carbonate (220 mg) in dioxane (5 ml) and methanol (3 ml) was heated at 100 °C for 12 h, then concentrated *in vacuo* and dissolved in acetone (10 ml). A solution of oxone (2.0 g) in water

and aq K<sub>2</sub>CO<sub>3</sub> (to keep the mixture at *ca.* pH 8) were added and stirred for 2 days. The mixture was extracted with ether (three times) and the organic extracts were dried (MgSO<sub>4</sub>), evaporated and purified by chromatography (silica, petrol – ether as eluent) to give the sub-title compound (319 mg).

5 <sup>1</sup>H NMR CDCl<sub>3</sub>: δ 8.17 (1H, d), 7.86 (1H, d), 7.71 (1H, dd), 7.32-7.27 (2H, m), 6.78 (1H, d), 4.67 (1H, q), 3.31 (3H, s), 1.52 (3H, d), 1.44 (9H, s).

**c) (2*S*)-2-[[3',5-Dichloro-4'-(methylsulfonyl)[1,1'-biphenyl]-2-yl]oxy]propanoic acid**

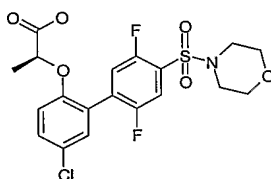
The title compound was prepared by the method of Example 2 step e) using the  
10 product of step b).

MS: ESI (+ve): 407 [M+NH<sub>4</sub>]<sup>+</sup> 100%

<sup>1</sup>H NMR DMSO-d<sub>6</sub>: δ 13.23 (1H, s), 8.07 (1H, d), 8.06 (1H, s), 7.87 (1H, dd), 7.52 (1H, d), 7.45 (1H, dd), 7.06 (1H, d), 5.03 (1H, q), 3.41 (3H, s), 1.46 (3H, d).

15 **Example 5**

**(2*S*)-2-[4-chloro-2-[2,5-difluoro-4-(4-morpholinylsulfonyl)phenoxy]phenoxy]-propanoic acid**



**a) 4-[(4-bromo-2,5-difluorophenyl)sulfonyl]-morpholine**

20 Morpholine (0.16 ml) was added to a stirred solution of 4-bromo-2,5-difluorobenzenesulfonyl chloride (0.18 g) in dichloromethane (6 ml) under nitrogen. The reaction mixture was stirred overnight and then quenched with water. The organic phase was dried (MgSO<sub>4</sub>) and concentrated *in vacuo* to give the sub-title compound as a white solid (200 mg).

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 7.62 (1H, dd), 7.52 (1H, dd), 3.77-3.7 (4H, m) and 3.23-3.2 (4H, m).

25

**b) Benzyl 2-bromo-4-chlorophenyl ether**

Benzyl bromide (13.1 ml) was added to a stirred mixture of 2-bromo-4-chlorophenol (20.7 g) and potassium carbonate (27.6 g) in DMF (200 ml). After 72 h, the mixture was partitioned between diethylether and water, the organic layer washed with water, dried and



the solvent evaporated under reduced pressure. The residue was purified by chromatography (silica, EtOAc/isohehexane as eluent). to give the sub-title compound (18.1 g).

$^1\text{H}$  NMR  $\text{CDCl}_3$ :  $\delta$  7.55 (1H, s) ; 7.46-7.18 (6H, m) ; 6.84 (1H, d) ; 5.14 (2H, s)

5 **c) [2-(Benzyloxy)-5-chlorophenyl]boronic acid**

A solution of butyl lithium (1.6 M in hexane) (50 ml) was added dropwise to a stirred solution of the product from step a) (23 g) in diethylether (300 ml) at  $-70^\circ\text{C}$ . After 1 h a further 18 ml of butyl lithium was added, left for 0.75 h, then trimethylborate (10 ml) added and the mixture warmed to RT and left for 16 h. 2 M Hydrochloric acid (100 ml) was added, 10 stirred for 1h then the organic layer separated and extracted with aqueous sodium hydroxide solution. The basic layer was acidified with 2 M hydrochloric acid solution, extracted with diethylether which was dried and evaporated under reduced pressure. The residue was triturated with iso-hexane and filtered to give the sub-title compound (10.8 g)

$^1\text{H}$  NMR  $\text{CDCl}_3$ :  $\delta$  7.82 (1H, d) ; 7.44-7.34 (6H, m) ; 6.90 (1H, d) ; 5.99 (2H, s) ; 5.12 (2H, s)

15

**d) 2-[5-Chloro-2-(phenylmethoxy)phenyl]-4,4,5,5-tetramethyl-1,3,2-dioxaboralane**

The sub-title compound was prepared from the product of step b) (5 g), pinacol (2.7 g) in anhydrous diethyl ether (200 ml). The reagents were stirred under nitrogen overnight. A further 1.2 g of pinacol and molecular sieves were added and stirred overnight. The reaction 20 mixture was washed with water, dried ( $\text{MgSO}_4$ ) and concentrated *in vacuo* to give the sub-title compound (5.6 g).

$^1\text{H}$  NMR  $\text{DMSO}-d_6$ :  $\delta$  7.27-7.64 (m, 7H), 6.85 (d, 1H), 5.09 (s, 2H), 1.36 (s, 12H)

**e) 4-Chloro-2-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenol**

25 The product from step d) was dissolved in ethanol (100 ml) and treated with palladium on activated carbon (5%), the suspension was stirred for 30 min under hydrogen (1 bar). The mixture was then filtered, and the filtrate was concentrated *in vacuo* to give the subtitle compound (4.2 g).

$^1\text{H}$  NMR  $\text{DMSO}-d_6$ :  $\delta$  7.76-7.79 (s, 1H), 6.79-7.62 (m, 3H), 1.36 (s, 12H)

**f) 1,1-Dimethylethyl 2-[4-Chloro-2-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenoxy]-(2*S*)-propanoate**

The subtitle compound was prepared by the method of Example 2 step a) using the product from step e) and tert-butyl (R)-(+)-lactate.

5

**g) 2-(2-Borono-4-chlorophenoxy)-(2*S*)-propanoic acid**

The subtitle compound was prepared by the method of Example 4 step a) using the product from step (f). Yield 2.5g. The crude material was carried forward to step h).

**h) (2*S*)-2-[4-chloro-2-[2,5-difluoro-4-(4-morpholinylsulfonyl)phenoxy]phenoxy]-propanoic acid**

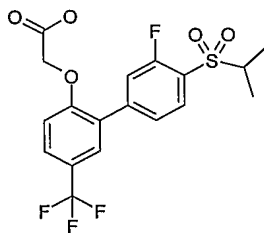
The product of step g) (0.1 g), the product of step a) (0.15 g), tetrakis palladiumtriphenylphosphine (0), sodium carbonate (2M solution, 4 ml), ethanol (4 ml) and toluene (8 ml) were heated at 90 °C for 18 h. The reaction mixture was cooled to room temperature, then concentrated in vacuo and further purified by reverse phase HPLC to give the title compound (0.1 g).

15

<sup>1</sup>H NMR DMSO-d<sub>6</sub>: δ 8.17-8.15 (1H, m), 7.63 (1H, t), 7.4 (2H, s), 7.0 (1H, s), 4.56 (1H, d), 3.6 (4H, m), 3.11 (4H, s) and 1.3 (3H, d).

**Example 6**

**[[3'-Fluoro-4'-[(1-methylethyl)sulfonyl]-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid**



**a) 4-Bromo-2-fluorobenzenethiol**

25

Triphenylphosphine was added portionwise to a solution of 4-bromo-2-fluorobenzenesulfonyl chloride (8.44 g) in THF (30 ml) at 0 °C. After 15 min water was added and the colourless solution was stirred at 20 °C for 18 h. The solvent was removed *in vacuo*, the residues dissolved in DCM and extracted with 2M sodium hydroxide (twice). The

aqueous layers were washed with DCM, combined, acidified (4M HCl) and extracted with ethyl acetate (thrice). These organic extracts were dried (MgSO<sub>4</sub>) and evaporated to give the sub-title compound (5.89 g).

MS: ESI (-ve): 206 [M-H]<sup>-</sup> 94%

5

**b) 4-Bromo-2-fluoro-[(1-methylethyl)thio]benzene**

A mixture of the product from step a) (2.77 g), *isopropyl*iodide (1.7 ml) and K<sub>2</sub>CO<sub>3</sub> (2.0 g) in acetone (10 ml) was stirred for 3 h. Water was added and the mixture was extracted with ether (three times). The organic extracts were dried (MgSO<sub>4</sub>) and, evaporated and to give  
10 the sub-title compound (3.22 g).

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 7.44-7.21 (3H, m), 3.41 (1H, heptet), 1.27 (6H, d).

**c) [3-Fluoro-4-[(1-methylethyl)thio]phenyl]boronic acid**

The sub-title compound was prepared by the method of Example 2 step c) using the  
15 product of step b).

MS: ESI (-ve): 213 [M-H]<sup>-</sup> 100%

**d) Methyl [2-bromo-4-(trifluoromethyl)phenoxy]acetate**

The sub-title compound was prepared by the method of Example 2 step a) using  
20 methyl bromoacetate and 2-bromo-4-(trifluoromethyl)phenol.

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 7.82 (1H, d), 7.48 (1H, dd), 6.81 (1H, d), 3.77 (3H, s).

**e) Methyl [[3'-fluoro-4'-[(1-methylethyl)sulfonyl]-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]acetate**

25 The sub-title compound was prepared by the method of Example 2 step d) using the products of step c) and step d).

MS: ESI (+ve): 452 [M+NH<sub>4</sub>]<sup>+</sup> 100%

**f) [[3'-Fluoro-4'-[(1-methylethyl)sulfonyl]-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid**  
30

A solution of the product from step e) (140 mg) in NaOH (0.35 ml, 1 M), THF (2 ml) and MeOH (1 ml) was stirred for 2 h. The solvent was removed *in vacuo* and the residue was

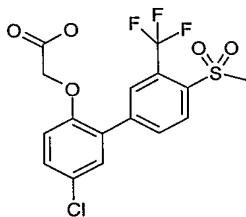
washed with ether, acidified (2M HCl) and extracted with DCM (thrice). The organic extracts were dried (MgSO<sub>4</sub>), evaporated and crystallised from *isohexane* – DCM to give the title compound (105 mg). M.p. 170-1 °C.

MS: ESI (+ve): 438 [M+NH<sub>4</sub>]<sup>+</sup> 100%

5 <sup>1</sup>H NMR DMSO-d<sub>6</sub>: δ 13.22 (1H, s), 7.90-7.78 (4H, m), 7.74 (1H, dd), 7.30 (1H, d), 4.92 (2H, s), 3.54 (1H, heptet), 1.25 (6H, d).

### **Example 7**

#### **[[5-Chloro-4'-(methylsulfonyl)-3'-(trifluoromethyl)][1,1'-biphenyl]-2-yl]oxy]-acetic acid**



#### **a) Methyl (4-chloro-2-iodophenoxy)acetate**

A mixture of 5-chloro-2-iodophenol (4.95 g), methyl bromoacetate (1.85 ml) and potassium carbonate (2.79 g) in acetonitrile (20 ml) was heated under reflux for 2 h. Aq HCl was added and the mixture was extracted with ether (three times). The organic extracts were  
15 dried (MgSO<sub>4</sub>), evaporated and purified by chromatography (silica, petrol – ether as eluent) to give the sub-title compound (5.75 g).

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 7.77 (1H, d), 7.25 (1H, dd), 6.64 (1H, d), 4.68 (2H, s), 3.81 (3H, s).

#### **b) Methyl [[5-chloro-4'-(methylsulfonyl)-3'-(trifluoromethyl)][1,1'-biphenyl]-2-yl]oxy]-acetate**

20 The sub-title compound was prepared by the method of Example 2 step d) using the products from step a) and Example 1 step b).

<sup>1</sup>H NMR DMSO-d<sub>6</sub>: δ 11.69 (1H, s), 8.30-8.27 (2H, m), 8.15 (1H, d), 7.58 (1H, d), 7.50 (1H, dd), 7.19 (1H, d), 4.82 (3H, s).

#### **25 c) [[5-Chloro-4'-(methylsulfonyl)-3'-(trifluoromethyl)][1,1'-biphenyl]-2-yl]oxy]-acetic acid**

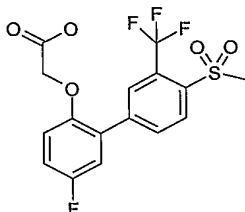
The sub-title compound was prepared by the method of Example 6 step f) using the product from step b).

MS: EPCI (+ve): 407  $[M+NH_4]^+$  100%

$^1H$  NMR DMSO- $d_6$ :  $\delta$  11.69 (1H, s), 8.33 (1H, d), 8.26 (1H, d), 8.15 (1H, dd), 7.57 (1H, d), 7.48 (1H, dd), 7.17 (1H, d), 4.82 (2H, s), 3.33 (3H, s).

## 5 **Example 8**

### **[[5-Fluoro-4'-(methylsulfonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid**



#### **a) Ethyl (2-bromo-4-fluorophenoxy)acetate**

The sub-title compound was prepared by the method of Example 2 step a) using 2-bromo-4-fluorophenol and ethyl bromoacetate.

MS: ESI (+ve): 277  $[M+H]^+$  100%

#### **b) Ethyl [[5-fluoro-4'-(methylsulfonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-acetate**

The sub-title compound was prepared by the method of Example 2 step d) (but in dioxane-ethanol) using the products from step a) and Example 1 step b).

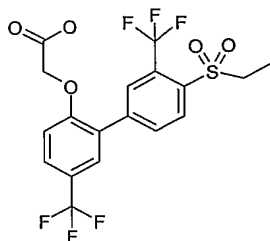
$^1H$  NMR  $CDCl_3$ :  $\delta$  8.35 (1H, d), 8.17 (1H, d), 8.01 (1H, dd), 7.14-7.06 (2H, m), 6.90-6.64 (1H, d), 4.63 (2H, s), 4.25 (2H, q), 3.23 (2H, s), 1.28 (3H, t).

#### **c) [[5-Fluoro-4'-(methylsulfonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid**

The title compound was prepared by the method of Example 6 step f) using the product from step b).

MS: EPCI (+ve): 407  $[M+NH_4]^+$  100%

$^1H$  NMR DMSO- $d_6$ :  $\delta$  8.35 (1H, d), 8.27 (1H, d), 8.17 (1H, dd), 7.40 (1H, dd), 7.28 (1H, d), 7.16 (1H, dd), 4.79 (2H, s), 3.32 (3H, s).

**Example 9****[[4'-(Ethylsulfonyl)-3',5-bis(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid****a) 4-Bromo-1-(ethylthio)-2-(trifluoromethyl)benzene**

5 The sub-title compound was prepared by the method of Example 2 step b) using sodium ethylthiolate and 4-bromo-1-fluoro-2-(trifluoromethyl)benzene.

$^1\text{H}$  NMR  $\text{CDCl}_3$ :  $\delta$  7.76 (1H, d), 7.58 (1H, dd), 7.32 (1H, d), 2.96 (2H, q), 1.31 (3H, t).

**b) 1-(Ethylthio)-2-(trifluoromethyl)phenyl]boronic acid**

10 The sub-title compound was prepared by the method of Example 2 step c) using the product from step a)

MS: ESI (-ve): 213  $[\text{M-H}]^-$  100%

**c) Methyl [2-bromo-4-(trifluoromethyl)phenoxy]acetate**

15 The sub-title compound was prepared by the method of Example 2 step a) using methyl bromoacetate and 2-bromo-4-(trifluoromethyl)phenol.

$^1\text{H}$  NMR  $\text{CDCl}_3$ :  $\delta$  7.82 (1H, d), 7.48 (1H, dd), 6.81 (1H, d), 3.77 (3H, s).

**d) Methyl [[4'-(ethylsulfonyl)-3',5-bis(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]acetate**

20 The sub-title compound was prepared by the method of Example 2 step d) using the products from steps b) and c).

MS: APCI (-ve): 469  $[\text{M-H}]^-$  100%

**e) [[4'-(Ethylsulfonyl)-3',5-bis(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid**

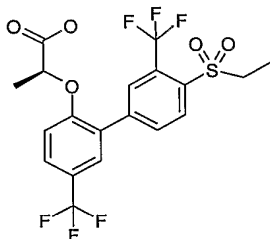
25 The title compound was prepared by the method of Example 5 step f) using the product from step d). M.p. 174-5 °C.

MS: ESI (-ve): 455  $[\text{M-H}]^-$  100%

$^1\text{H}$  NMR DMSO- $d_6$ :  $\delta$  8.38 (1H, d), 8.24 (1H, d), 8.18 (1H, dd), 7.84-7.80 (2H, m), 7.33 (1H, d), 4.91 (2H, s), 3.41 (2H, q), 1.21 (3H, t).

### Example 10

5 **(2S)- 2-[[4'-(Ethylsulfonyl)-3',5-bis(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]propanoic acid**



**a) 1,1-Dimethylethyl (2S)- 2-[[4'-(ethylsulfonyl)-3',5-bis(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]propanoate**

10 The sub-title compound was prepared by the method of Example 2 step d) using the products from step b) and Example 1 step b).

MS: APCI (-ve): 525  $[\text{M-H}]^-$  100%

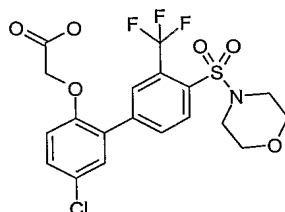
15 **b) (2S)- 2-[[4'-(Ethylsulfonyl)-3',5-bis(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]propanoic acid**

The sub-title compound was prepared by the method of Example 2 step e) using the product from step a). M.p. 124-6 °C.

MS: ESI (-ve): 469  $[\text{M-H}]^-$  100%

$^1\text{H}$  NMR DMSO- $d_6$ :  $\delta$  8.47 (1H, d), 8.26-8.19 (2H, m), 8.18 (1H, dd), 7.82 (1H, dd), 7.25 (1H, d), 5.20 (1H, q), 3.41 (2H, q), 1.48 (3H, d), 1.21 (3H, t).

20

**Example 11****[[5-Chloro-4'-(4-morpholinylsulfonyl)-3'-(trifluoromethyl)][1,1'-biphenyl]-2-yl]oxy]acetic acid****5 a) 4-[[4-Bromo-2-(trifluoromethyl)phenyl]sulfonyl]morpholine**

Morpholine (1.1 ml) was added to a solution of [4-bromo-2-(trifluoromethyl)phenyl]sulfonyl chloride ( 2.03 g) in DCM (7 ml) at 0 °C and stirred at 20 °C for 16 h. Water was added and the mixture was extracted with DCM. The organic extracts

10 were dried (MgSO<sub>4</sub>), evaporated and purified by chromatography (silica, petrol – ether as

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 8.04 (1H, d), 7.97 (1H, d), 7.85 (1H, dd), 3.73 (4H, t), 3.23 (4H, t).

**b) 4-[[5'-Chloro-2'-(phenylmethoxy)-3-(trifluoromethyl)[1,1'-biphenyl]-4-yl]sulfonyl-morpholine**

15 A mixture of the product of step a) (450 mg) and [5-chloro-2-(phenylmethoxy)phenyl]boronic acid (351 mg), sodium carbonate (277 mg) and Pd(dppf)Cl<sub>2</sub> (93 mg) in dioxan (3 ml) and methanol (0.5 ml) was heated at 85 °C for 16 h. Water was added and the mixture was extracted with ether (three times), the organic extracts were dried (MgSO<sub>4</sub>), evaporated and purified by chromatography (silica, petrol – ether as eluent) to give

20 the sub-title compound (538 mg).

M.p. 118-9 °C.

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 8.13–8.04 (2H, m), 7.83 (1H, dd), 7.37-7.26 (7H, m), 7.04 (1H, d), 5.09 (2H, s), 3.74 (4H, t), 3.25 (4H, t).

**25 c) 4-[[5'-Chloro-2'-hydroxy-3-(trifluoromethyl)[1,1'-biphenyl]-4-yl]sulfonyl]morpholine**

Boron tribromide (2.5 ml, 1.0 M in DCM) was added to a solution of the product from step b) (1.16 g) in DCM (15 ml) at 0 °C. The solution was stirred for 15 min then quenched with water. The mixture was extracted with DCM (three times), the organic extracts were



dried ( $\text{MgSO}_4$ ), evaporated and purified by chromatography (silica, petrol – ether as eluent) to give the sub-title compound (851 mg).

MS: ESI (-ve): 420  $[\text{M-H}]^-$  100%

5 **d) Ethyl [[5-chloro-4'-(4-morpholinylsulfonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]acetate**

The sub-title compound was prepared by the method of Example 2 step a) using the product from steps c) and ethyl bromoacetate.

MS: ESI (+ve): 508  $[\text{M+H}]^+$  100%

10

**e) [[5-Chloro-4'-(4-morpholinylsulfonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid**

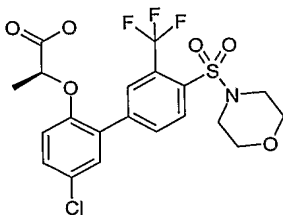
The sub-title compound was prepared by the method of Example 5 step f) using the product from step d). M.p. 208-9 °C.

15 MS: ESI (-ve): 478  $[\text{M-H}]^-$  100%

$^1\text{H}$  NMR DMSO- $d_6$ :  $\delta$  8.31 (1H, d), 8.11 (2H, d), 7.56 (1H, d), 7.41 (1H, dd), 7.16 (1H, d), 4.80 (2H, s), 3.66 (4H, t), 3.19 (4H, t).

**Example 12**

20 **(2S)-2-[[5-Chloro-4'-(4-morpholinylsulfonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]propanoic acid**



**a) 1,1-Dimethylethyl (2S)-2-[[5-chloro-4'-(4-morpholinylsulfonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]propanoate**

25 The sub-title compound was prepared by the method of Example 4 step a) using the product from Example 11 step c).

$^1\text{H}$  NMR  $\text{CDCl}_3$ :  $\delta$  8.27 (1H, d), 8.14 (1H, d), 7.93 (1H, dd), 7.35 (1H, d), 7.30 (1H, dd), 6.80 (1H, d), 4.70 (1H, q), 3.76 (4H, t), 3.28 (4H, t), 1.52 (3H, d), 1.42 (9H, s).

**b) (2S)-2-[[5-Chloro-4'-(4-morpholinylsulfonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]propanoic acid**

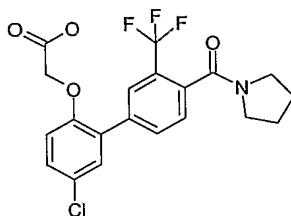
The sub-title compound was prepared by the method of Example 2 step e) using the  
5 product from step a). M.p. 148-9 °C.

MS: ESI (-ve): 492 [M-H]<sup>-</sup> 100%

<sup>1</sup>H NMR DMSO-d<sub>6</sub>: δ 13.26 (1H, s), 8.44 (1H, d), 8.12 (2H, s), 7.58 (1H, d), 7.47 (1H, dd),  
7.08 (1H, d), 5.07 (1H, q), 3.66 (4H, t), 3.20 (4H, t), 1.45 (3H, d).

10 **Example 13**

**[[5-Chloro-4'-(1-pyrrolidinylcarbonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-  
acetic acid**



**a) 4-Bromo-2-(trifluoromethyl)- benzoic acid**

15 A mixture of 1-bromo-4-fluoro-3-(trifluoromethyl)benzene (5.02 g) and potassium cyanide (1.38 g) in DMSO (20 ml) was heated at 80 °C for 14 h. Water was added and the mixture was extracted ether, the organic extracts were dried (MgSO<sub>4</sub>) and evaporated to give a brown oil. This was dissolved in DMSO (10 ml) and 4 M NaOH (10 ml) and heated at 100 °C for 16 h. 2 M HCl (20 ml) was added and the mixture was extracted with DCM (three  
20 times), the organic extracts were dried (MgSO<sub>4</sub>), evaporated and purified by chromatography (silica, CH<sub>2</sub>Cl<sub>2</sub>-MeOH-AcOH as eluent) to give the sub-title compound (1.99 g).

MS: ESI (-ve): 268 [M-H]<sup>-</sup> 100%.

**b) 1-[4-Bromo-2-(trifluoromethyl)benzoyl]pyrrolidine**

25 EDCI (1.70 g) was added to a solution of the product from step a) (1.97 g), pyrrolidine (1.2 ml) and DMAP (1.43 g) in DCM (10 ml) and THF (2 ml) and the resultant solution was stirred for 16 h. Aq HCl was added and the mixture was extracted with DCM (three times),

the organic extracts were dried (MgSO<sub>4</sub>), evaporated and purified by chromatography (silica, petrol – ether as eluent) to give the sub-title compound (616 mg).

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 8.27 (1H, d), 7.93 (1H, d), 7.74 (1H, dd), 7.25 (1H, d), 3.64 (2H, t), 3.11 (2H, t), 1.98 (2H, hex), 1.88 (2H, hex).

5

**c) 1-[[5'-Chloro-2'-(phenylmethoxy)-3-(trifluoromethyl)[1,1'-biphenyl]-4-yl]carbonyl]-pyrrolidine**

The sub-title compound was prepared by the method of Example 11 step b) using the product of step b) and [5-chloro-2-(phenylmethoxy)phenyl]boronic acid. M.p. 143-4 °C.

10 MS: ESI (+ve): 460 [M+H]<sup>+</sup> 100%

**d) 1-[[5'-Chloro-2'-hydroxy-3-(trifluoromethyl)[1,1'-biphenyl]-4-yl]carbonyl]pyrrolidine**

The sub-title compound was prepared by the method of Example 11 step c) using the product of step c). M.p. 220-1 °C.

15 MS: ESI (-ve): 368 [M-H]<sup>-</sup> 100%.

**e) Ethyl [[5-chloro-4'-(1-pyrrolidinylcarbonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-acetate**

20 The sub-title compound was prepared by the method of Example 2 step a) using the product from steps d) and ethyl bromoacetate.

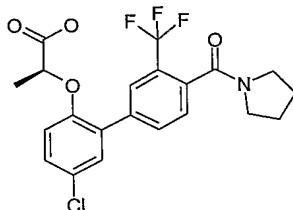
<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 7.92 (1H, s), 7.81 (1H, dd), 7.41 (1H, d), 7.33-7.28 (2H, m), 6.82 (1H, d), 4.61 (2H, s), 4.24 (2H, q), 3.68 (2H, t), 3.20 (2H, t), 1.98 (2H, hex), 1.90 (2H, hex), 1.26 (3H, t).

25 **f) [[5-Chloro-4'-(1-pyrrolidinylcarbonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid**

The title compound was prepared by the method of Example 5 step f) using the product from step e). M.p. 197-8 °C.

MS: ESI (-ve): 426 [M-H]<sup>-</sup> 100%

30 <sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 8.09 (1H, s), 8.01 (1H, d), 7.51 (1H, d), 7.41 (1H, d), 7.32 (1H, d), 6.97 (1H, d), 4.42 (2H, s), 3.47 (2H, t), 3.10 (2H, t), 1.93-1.78 (4H, m).

**Example 14****(2S)-2-[[5-Chloro-4'-(1-pyrrolidinylcarbonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy] propanoic acid**

- 5 a) 1,1-Dimethylethyl (2S)-2-[[5-Chloro-4'-(1-pyrrolidinylcarbonyl)-3'-(trifluoromethyl)-[1,1'-biphenyl]-2-yl]oxy] propanoate

The sub-title compound was prepared by the method of Example 4 step a) using the product from Example 13 step d).

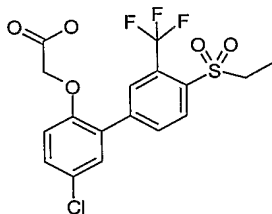
<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 8.03 (1H, s), 7.80 (1H, d), 7.40 (1H, dd), 7.31 (1H, d), 7.26-7.24 (1H, m),  
 10 6.77 (1H, d), 4.64 (1H, q), 3.68 (2H, t), 3.20 (2H, t), 1.99 (2H, hex), 1.90 (2H, hex), 1.49 (3H, d), 1.41 (9H, s).

**b) (2S)-2-[[5-Chloro-4'-(1-pyrrolidinylcarbonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy] propanoic acid**

15 The sub-title compound was prepared by the method of Example 2 step e) using the product from step a). M.p. 164-5 °C.

MS: ESI (-ve): 440 [M-H]<sup>-</sup> 100%

<sup>1</sup>H NMR DMSO-d<sub>6</sub>: δ 13.26 (1H, s), 8.44 (1H, d), 8.12 (2H, s), 7.58 (1H, d), 7.47 (1H, dd),  
 20 7.08 (1H, d), 5.07 (1H, q), 3.66 (4H, t), 3.20 (4H, t), 1.45 (3H, d).

**Example 15****[[5-Chloro-4'-(ethylsulfonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid**

**a) Methyl [[5-chloro-4'-(ethylsulfonyl)-3'-(trifluoromethyl)][1,1'-biphenyl]-2-yl]oxy]acetate**

The sub-title compound was prepared by the method of Example 2 step d) using the products from Example 7 step a) and Example 9 step b).

5 MS: APCI (-ve): 435 [M-H]<sup>-</sup> 100%

**b) [[5-Chloro-4'-(ethylsulfonyl)-3'-(trifluoromethyl)][1,1'-biphenyl]-2-yl]oxy]acetic acid**

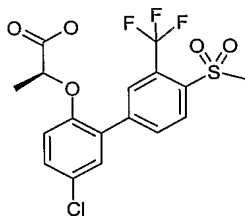
The title was prepared by the method of Example 6 step f) using the product from step a).

10 MS: ESI (-ve): 421 [M-H]<sup>-</sup> 100%

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 8.35 (1H, d), 8.21 (1H, d), 8.15 (1H, dd), 7.58 (1H, d), 7.48 (1H, dd), 7.17 (1H, d), 4.82 (2H, s) 3.42 (2H, q), 1.21 (3H, t).

**Example 16**

15 **(2S)- 2-[[5-Chloro4'-(methylsulfonyl)-(3'-trifluoromethyl)-[1,1'-biphenyl]-2-yl]oxy]propanoic acid**



20 **Methyl (2S)- 2-[[5-chloro4'-(methylsulfonyl)-(3'-trifluoromethyl)-[1,1'-biphenyl]-2-yl]oxy]propanoate**

The sub-title compound was prepared by the method of Example 2 step d) using the products from Example 4 step b) and Example 1 step b). Extensive saponification occurred during this reaction and the product was re-esterified using trimethylsilyldiazomethane in methanol.

25 MS: APCI (-ve): 435 [M-H]<sup>-</sup> 100%

**(2S)- 2-[[5-Chloro4'-(methylsulfonyl)-(3'-trifluoromethyl)-[1,1'-biphenyl]-2-yl]oxy]propanoic acid**

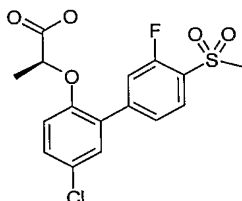
The sub-title compound was prepared by the method of Example 6 step f) using the product from step a). M.p. 77-9 °C.

5 MS: ESI (-ve): 421 [M-H]<sup>-</sup> 100%

<sup>1</sup>H NMR DMSO-d<sub>6</sub>) δ 8.48 (s, 1H), 8.28 (d, 1H), 8.18 (d, 1H), 7.58 (s, 1H), 7.47 (d, 1H), 7.09 (d, 1H), 5.06 (q, 1H), 3.40 (s, 3H), 1.45 (d, 3H)

**Example 17**

10 **(2S)- 2-[[5-Chloro-3'-fluoro-4'-(methylsulfonyl)[1,1'-biphenyl]-2-yl]oxy]propanoic acid**



a) **[3-Fluoro-4-(methylthio)phenyl] boronic acid**

The sub-title compound was prepared by the method of Example 1 step c) using the product of step b).

15 MS: ESI (-ve): 185 [M-H]<sup>-</sup> 100%

**b) 1,1-Dimethylethyl (2S)- 2-[[5-Chloro-3'-fluoro-4'-(methylsulfonyl)[1,1'-biphenyl]-2-yl]oxy]propanoate**

20 The sub-title compound was prepared by the method of Example 2 step d) using the products from step a) and Example 4 step a).

<sup>1</sup>H NMR DMSO-d<sub>6</sub>: δ 7.91 (1H, t), 7.82 (1H, dd), 7.73 (1H, dd), 7.52 (1H, d), 7.47 (1H, dd), 7.03 (1H, d), 4.99 (1H, q), 3.38 (3H, s), 1.44 (3H, d), 1.38 (9H, s).

25 **c) (2S)- 2-[[5-Chloro-3'-fluoro-4'-(methylsulfonyl)[1,1'-biphenyl]-2-yl]oxy]propanoic acid**

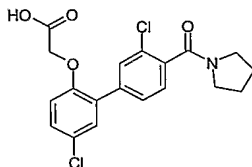
The sub-title compound was prepared by the method of Example 2 step e) using the product from step a). M.p. 190-2 °C.

MS: ESI (-ve): 371 [M-H]<sup>-</sup> 100%

$^1\text{H}$  NMR DMSO- $d_6$ :  $\delta$  7.92-7.82 (2H, m), 7.74 (1H, dd), 7.50 (1H, d), 7.46 (1H, dd), 7.05 (1H, d), 5.02 (1H, q), 3.38 (3H, s), 1.46 (3H, d).

### Example 18

#### 5 [[3',5'-dichloro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid



#### a) 1-(4-bromo-2-chlorobenzoyl)-pyrrolidine

Oxalyl chloride (0.56 ml) was added to a stirred suspension of 4-bromo-2-chlorobenzoic acid (0.5 g) in dichloromethane (10 ml). DMF (1 drop was added) and stirred for 1 h, then evaporated *in vacuo*. The product was dissolved in DCM (10 ml), triethylamine (0.21 ml) was added, followed by pyrrolidine (0.27 ml) and stirred overnight. Water was added and the organic layer separated, then washed with 1M HCl, dried ( $\text{MgSO}_4$ ) and evaporated *in vacuo*. Yield 0.6 g  
MS: ESI (-ve): 249 (M-H)

#### 15 b) 1-[(3,5'-dichloro-2'-methoxy[1,1'-biphenyl]-4-yl)carbonyl]-pyrrolidine

The product of step a) (0.6 g), 4-chloro-2-methoxy benzoic acid (0.69 g), toluene (10 ml), ethanol (4 ml) and 2M  $\text{Na}_2\text{CO}_3$  (2 ml) were charged to a flask and stirred. Tetrakis(triphenylphosphine) palladium (0) (0.09 g) was added and the mixture stirred at reflux for 16 h. The mixture was concentrated *in vacuo*. The residue was purified by flash column chromatography eluting with isohexane:ethyl acetate (6:4) to give the sub-title compound. Yield 0.68g.  
MS: ESI (+ve): 350 (M+H)

#### 25 c) 1-[(3,5'-dichloro-2'-hydroxy[1,1'-biphenyl]-4-yl)carbonyl]-pyrrolidine

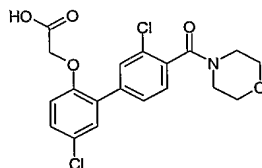
The product from step b) (0.6 g) was dissolved in DCM (20 ml) and treated with boron tribromide (7 ml) and stirred for 1 h. Ice was added and a solid formed, which was filtered to give the sub-title compound. Yield 0.46 g.  
MS: ESI (-ve): 335 (M-H)

**d) [[3',5-dichloro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid**

The product from step c) (180 mg), *tert*-butyl bromoacetate (0.07 ml), potassium carbonate (0.1 g) and DMF (10 ml) were charged to a flask and stirred for 16 h. Water was added and then washed with ethyl acetate. The organic extracts were dried (MgSO<sub>4</sub>) and evaporated *in vacuo*. The residue was purified by flash column chromatography eluting with isohexane:ethyl acetate (8:2). The sub-title compound was dissolved in DCM (8 ml) and TFA (2 ml) was added, stirred for 1 h, then concentrated *in vacuo*. Trituration with a mixture of ether and isohexane gave a solid, which was further purified by reverse phase HPLC to give the title compound. Yield (48 mg)

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 7.81 (1H, s), 7.64 (1H, d), 7.42-7.35 (3H, m), 7.02 (1H, d), 4.6 (2H, s), 3.58-3.01 (6H, m) and 1.86 (2H, d).

MS: APCI (-ve): 392 (M-H)

**Example 19****[[3',5-dichloro-4'-(4-morpholinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid****a) 4-(4-bromo-2-chlorobenzoyl)-morpholine**

The sub-title compound was prepared by the method of example 18 part a) using morpholine

MS: ESI (-ve): 306 (M-H)

**b) 4-[(3,5'-dichloro-2'-hydroxy[1,1'-biphenyl]-4-yl)carbonyl]-morpholine**

The sub-title compound was prepared by the methods of example 18 step b) and c) using the product from step a) and 4-chloro-2-methoxy boronic acid.

MS: ESI (-ve): 351 (M-H)

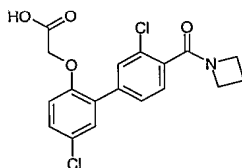


**c) [[3',5-dichloro-4'-(4-morpholinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid**

The title compound was prepared by the method of example 18 step d) using the product of step b).

<sup>1</sup>H NMR DMSO-D6: δ 7.81 (1H, s), 7.67 (1H, d), 7.73-7.30 (3H, m), 7.04 (1H, d), 4.64 (2H, s), 3.72-3.50 (6H, m) and 3.22 (2H, t).

MS: APCI (-ve): 408 (M-H)

**Example 20****[[4'-(1-azetidiny carbonyl)-3',5-dichloro[1,1'-biphenyl]-2-yl]oxy]-acetic acid****a) 1-(4-bromo-2-chlorobenzoyl)-azetidine**

The sub-title compound was prepared by the method of example 18 part a) using azetidine hydrochloride

MS: ESI (-ve): 273 (M-H)

**b) 1-[(3,5'-dichloro-2'-methoxy[1,1'-biphenyl]-4-yl)carbonyl]-azetidine**

The sub-title compound was prepared by the method of example 18 steps b) and c) using the product from step a) and 4-chloro-2-methoxy boronic acid.

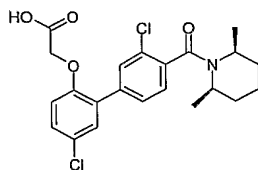
MS: ESI (+ve): 322 (M+H)

**c) [[4'-(1-azetidiny carbonyl)-3',5-dichloro[1,1'-biphenyl]-2-yl]oxy]-acetic acid**

The title compound was prepared by the method of example 18 step d) using the product of step b).

<sup>1</sup>H NMR DMSO-D6: δ 7.82 (1H, s), 7.7 (1H, d), 7.43 (1H, d), 7.38-7.29 (2H, m), 6.93 (1H, d), 4.36 (2H, s), 4.16 (2H, t), 3.96 (2H, t) and 2.3 (2H, q).

MS: APCI (-ve): 378 (M-H)

**Example 21****[[3',5'-dichloro-4'-[(2*R*,6*S*)-2,6-dimethyl-1-piperidinyl]carbonyl][1,1'-biphenyl]-2-yl]oxy]-acetic acid****a) 3,5'-dichloro-2'-methoxy-[1,1'-biphenyl]-4-carboxylic acid**

4-bromo-2-chlorobenzoic acid (0.4 g), 5-chloro-2-methoxybenzoic acid (0.4 g), Pd(dppf)Cl<sub>2</sub> (0.12 g), sodium carbonate (0.9 g), dioxan (15 ml) and methanol (5 ml) were charged to a flask and heated at reflux for 16 h. Cooled to room temp and filtered (hyflo). The filtrate was concentrated *in vacuo*, then dissolved in ethyl acetate. The suspension was made basic by addition of dilute NaOH. The aqueous layer was separated and acidified using 2M HCl, extracted with EtOAc, dried (MgSO<sub>4</sub>) and evaporated *in vacuo* to give the sub-title compound Yield 0.4 g

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 13.37 (1H, s), 7.86 (1H, m), 7.64 (1H, s), 7.41-7.38 (3H, m), 7.2 (1H, d) and 3.8 (3H, s).

**b) (2*R*,6*S*)-1-[(3,5'-dichloro-2'-methoxy[1,1'-biphenyl]-4-yl)carbonyl]-2,6-dimethylpiperidine**

The sub-title compound was prepared by the method of example 18 step a) using the product of step a) and 2,6-dimethyl *cis*-piperazine.

MS: ESI (+ve): 393 (M+H)

**c) (2*R*,6*S*)-1-[(3,5'-dichloro-2'-hydroxy[1,1'-biphenyl]-4-yl)carbonyl]-2,6-dimethylpiperidine**

The sub-title compound was prepared by the method of example 18 step c) using the product of step b).

MS: ESI (+ve): 378 (M+H)

**d) [[3',5'-dichloro-4'-[(2*R*,6*S*)-2,6-dimethyl-1-piperidinyl]carbonyl][1,1'-biphenyl]-2-yl]oxy]-acetic acid**

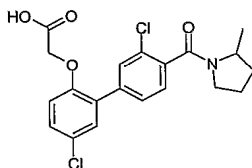
The title compound was prepared by the method of example 18 step d) using the product of step c).

$^1\text{H}$  NMR DMSO-D<sub>6</sub>:  $\delta$  7.78 (1H, dd), 7.64-7.57 (1H, m), 7.43-7.3 (3H, m), 7.1-7.02 (1H, m), 4.97 (2H, s), and 1.96-1.04 (14H, m).

5 MS: APCI (-ve): 436 (M-H)

### **Example 22**

#### **[[3',5-dichloro-4'-[(2-methyl-1-pyrrolidinyl)carbonyl][1,1'-biphenyl]-2-yl]oxy]-acetic acid**



10

#### **a) 1-[(3,5'-dichloro-2'-methoxy[1,1'-biphenyl]-4-yl)carbonyl]-2-methyl-pyrrolidine**

The sub-title compound was prepared by the method of example 18 step a) using the product of step example 21 step a) and 2-methyl pyrrolidine.

15 MS: ESI (+ve): 364 (M+H)

#### **b) 1-[(3,5'-dichloro-2'-hydroxy[1,1'-biphenyl]-4-yl)carbonyl]-2-methyl-pyrrolidine**

The sub-title compound was prepared by the method of example 18 step c) using the product of step a).

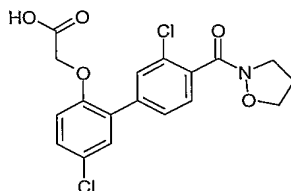
20 MS: ESI (+ve): 350 (M+H)

#### **c) [[3',5-dichloro-4'-[(2-methyl-1-pyrrolidinyl)carbonyl][1,1'-biphenyl]-2-yl]oxy]-acetic acid**

The title compound was prepared by the method of example 18 step d) using the product of step b).

$^1\text{H}$  NMR DMSO-D<sub>6</sub>:  $\delta$  7.73 (1H, s), 7.6 (1H, d), 7.42-7.35 (3H, m), 7.06 (1H, d), 4.68 (2H, s), 4.2-4.13 (1H, m), 3.24-2.82 (2H, m, + DMSO), 2.17-1.51 (4H, m) 1.23 (3H, d) and 0.98-0.86 (1H, m).

MS: APCI (-ve): 378 (M-H)

**Example 23****[[3',5'-dichloro-4'-(2-isoxazolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid**5 **a) 2-[(3,5'-dichloro-2'-methoxy[1,1'-biphenyl]-4-yl)carbonyl]-isoxazolidine**

The sub-title compound was prepared by the method of example 21 step b) using the product of example 21 step a) and isoxazolidine.

MS: ESI (+ve): 352 (M+H)

10 **b) 2-[(3,5'-dichloro-2'-hydroxy[1,1'-biphenyl]-4-yl)carbonyl]-isoxazolidine**

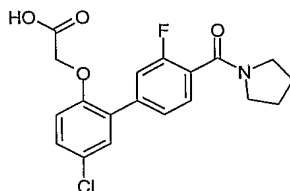
The sub-title compound was prepared by the method of example 18 part c) using the product of step a).

MS: ESI (+ve): 338 (M+H)

15 **c) [[3',5'-dichloro-4'-(2-isoxazolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid**

The title compound was prepared by the method of example 18 step d) using the product of step b).

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 7.84 (1H, s), 7.62 (1H, dd), 7.42 (1H, d), 7.38-7.29 (2H, m), 6.93 (1H, d), 4.32 (2H, s), 3.93 (2H, t), 3.7 (2H, t, broad) and 2.39-2.22 (2H, m).

20 **MS: APCI (+ve): 396 (M+H)****Example 24****[[5-chloro-3'-fluoro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid**25 **a) 1-(4-bromo-2-fluorobenzoyl)-pyrrolidine**

The sub-title compound was prepared by the method of example 18 step a) using 4-bromo-2-fluoro-benzoic acid and pyrrolidine.

**b) 1-[(5'-chloro-3-fluoro-2'-methoxy[1,1'-biphenyl]-4-yl)carbonyl]-pyrrolidine**

5 The sub-title compound was prepared by the method of example 18 step b) using the product from step a) and 4-chloro-2-methoxy boronic acid.

MS: ESI (-ve): 333 (M+H)

**c) 1-[(5'-chloro-3-fluoro-2'-hydroxy[1,1'-biphenyl]-4-yl)carbonyl]-pyrrolidine**

10 The sub-title compound was prepared by the method of example 18 step c) using the product of step b).

MS: ESI (+ve): 320 (M+H)

**d) [[5-chloro-3'-fluoro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid, ethyl ester**

15 The product of step c) (0.11 g) was dissolved in DMF (5 ml), ethylbromoacetate (0.04 ml) and potassium carbonate (0.1 g) were added. The reaction mixture was stirred for 16 h at RT. Water and ethyl acetate were added. The organic layer was removed, dried (MgSO<sub>4</sub>) and evaporated *in vacuo*. The residue was purified by flash column chromatography eluting with  
20 isohexane:ethyl acetate (1:1) to give the sub-title compound. Yield 0.12g.

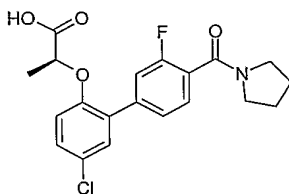
MS: ESI (+ve): 406 (M+H)

**e) [[5-chloro-3'-fluoro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid**

25 The title compound was prepared by the method of example 6 step f) using the product of step d).

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 13.12 (1H, s), 7.6-7.4 (5H, m), 7.08 (1H, d), 4.8 (2H, s), 3.48-3.46 (2H, m), 3.38-3.13 (2H, m), 1.91-1.84 (4H, m).

MS: APCI (-ve): 376 (M-H)

**Example 25****(2S)-2-[[5-chloro-3'-fluoro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

5

**a) (2S)-2-[[5-chloro-3'-fluoro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-1,1-dimethylethyl ester, propanoic acid**

The sub-title compound was prepared by the method of example 1 step e) using the product of example 24 step c)

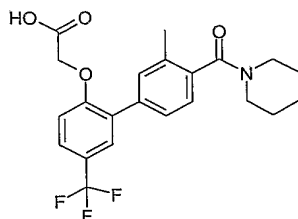
10 MS: ESI (+ve): 448 (M+H)

**b) (2S)-2-[[5-chloro-3'-fluoro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

The product of step a) (0.23 g) was dissolved in dichloromethane (6 ml) and TFA (1.5  
15 ml) was added, the solution was stirred for 2 hours, then concentrated *in vacuo*, diluted with 1M NaOH and ethyl acetate. The aqueous layer was separated and acidified using 2M HCl, then extracted with ethyl acetate (x 2). The organic layers were dried (MgSO<sub>4</sub>) and evaporated *in vacuo* to give the title compound. Yield 0.18 g.

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 7.67-7.44 (5H, m), 7.07 (1H, d), 5.03 (1H, q), 3.58 (2H, t), 3.25 (2H,  
20 t), 2.02-1.83 (4H, m), 1.5 (3H, d).

MS: APCI (-ve): 390 (M-H)

**Example 26****[[3'-methyl-4'-(1-piperidinylcarbonyl)-5-(trifluoromethyl)][1,1'-biphenyl]-2-yl]oxy]-acetic acid**

5

**a) [2-borono-4-(trifluoromethyl)phenoxy]-acetic acid, 1,1-dimethylethyl ester**

To a flask, purged with nitrogen, was charged *bis*(dibenzylideneacetone)palladium(0) (1.4 g), tricyclohexylphosphine (0.57 g), potassium acetate (4.14 g), [2-bromo-4-(trifluoromethyl)phenoxy]-acetic acid, 1,1-dimethylethyl ester [WO2004089885] (10 g), dioxane (80 ml) and bis(pinacolato)diboron (7.86 g). The mixture was heated to 100 °C for 3 hours, cooled and then filtered before water (50 ml) was added to the filtrates which were stirred overnight at room temperature. The mixture was poured into water (300 ml), extracted with ethylacetate, washed with brine, dried (MgSO<sub>4</sub>) and concentrated *in vacuo* to give crude material. Purification using flash column chromatography (eluent 10% ethylacetate/hexane increasing to 20% ethylacetate/hexane) gave the sub-title compound as a solid (4.1 g).

<sup>1</sup>H NMR DMSO-d<sub>6</sub>: δ 8.03 (2H, s), 7.91 (1H, d), 7.76 (1H, t), 7.13 (1H, d), 4.83 (2H, s), 1.47 (9H, s).

10

15

**b) 1-(4-bromo-2-methylbenzoyl)-piperidine**

The sub-title compound was prepared by the method of example 18 step a) using 4-bromo-2-methyl benzoic acid and piperidine.

20

MS: ESI (+ve): 282 (M+H)

**c) [[3'-methyl-4'-(1-piperidinylcarbonyl)-5-(trifluoromethyl)][1,1'-biphenyl]-2-yl]oxy]-acetic acid**

25

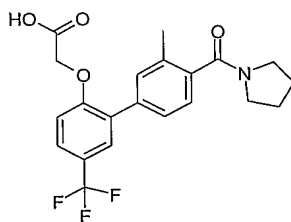
The title compound was prepared by the method of example 21 step a) using the products of step a) and step b).

$^1\text{H}$  NMR DMSO- $\text{D}_6$ :  $\delta$  7.67-(1H, d), 7.6 (1H, s), 7.45-7.41 (2H, m), 7.19-7.13 (2H, m), 4.72 (2H, s), 3.65-3.6 (2H, m), 3.17 (2H, t), 2.25 (3H, s), 1.62-1.39 (6H, m).

MS: APCI (-ve): 420 (M-H)

### 5 **Example 27**

**[[3'-methyl-4'-(1-pyrrolidinylcarbonyl)-5-(trifluoromethyl)-1,1'-biphenyl]-2-yl]oxy]-acetic acid**



#### **a) 1-(4-bromo-2-methylbenzoyl) pyrrolidine**

10 The sub-title compound was prepared by the method of example 18 step a) using 4-bromo-2-methyl benzoic acid and pyrrolidine.

MS: ESI (+ve): 268 (M+H)

#### **b) [[3'-methyl-4'-(1-pyrrolidinylcarbonyl)-5-(trifluoromethyl)-1,1'-biphenyl]-2-yl]oxy]-**

### 15 **acetic acid**

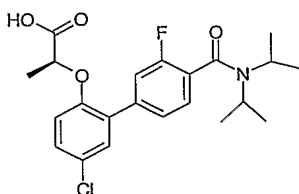
The title compound was prepared by the method of example 21 step a) using the product of step a) and the product of example 26 step a).

$^1\text{H}$  NMR DMSO- $\text{D}_6$ :  $\delta$  13.08 (1H, s), 7.7-7.42 (4H, m), 7.31-7.18 (2H, m), 4.86 (2H, s), 3.49 (2H, t), 3.13(2H, t), 2.26 (3H, s), 1.91-1.8 (4H, m).

20 MS: APCI (-ve): 407 (M-H)

### **Example 28**

**(2S)-2-[[4'-[[bis(1-methylethyl)amino]carbonyl]-5-chloro-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**





**a) 2-[5-chloro-2-(phenylmethoxy)phenyl]-4,4,5,5-tetramethyl-1,3,2-dioxaborolane**

Pinacol (3.24 g) was added to a solution of [5-chloro-2-(phenylmethoxy)phenyl]-boronic acid (6 g) in diethyl ether, and stirred for 24 h. 4A molecular sieves and pinacol (1.5 g) were added, stirred for a further 24 h. The sieves were filtered and the filtrate was washed with water and brine, then dried (MgSO<sub>4</sub>) and concentrated *in vacuo*. Yield 6.8 g.  
<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 7.6-7.25 (7H, m), 7.08 (1H, d), 5.13 (2H, s), 1.32 (12H, s)

**b) 4-chloro-2-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-phenol**

10 10% Palladium on activated carbon was added to a solution of the product from step a) (4 g) in ethanol (100 ml), and stirred under 1 bar hydrogen for 30 min. The mixture was filtered and the filtrate was concentrated *in vacuo* to give the sub-title compound. Yield 3.51 g. Used without characterisation.

**15 c) (2S)-2-(2-borono-4-chlorophenoxy)-propanoic acid**

DIAD (3 ml) was added to a mixture of the product from step b) (3.51 g), triphenyl phosphine (3.98 g), tert-butyl (R)-(+)-lactate (2.02 g) and THF (80 ml) at 0°C overnight. The mixture was concentrated *in vacuo*. The residue was purified by flash column chromatography eluting with isohexane:ethyl acetate (7:3) to give the sub-title compound (4 g). The intermediate obtained was dissolved in acetone and 1M HCl (15 ml) was added, stirred for 20 min, then concentrated *in vacuo*. Redissolved in dichloromethane (10 ml) and added TFA (5 ml). Stirred for 2 h, then added water (1 ml), stirred for 1 h. The reaction mixture was then diluted (water) and made alkaline by adding dilute NaOH. The organic layer was separated and discarded. The aqueous phase was acidified with concentrated HCl to pH1, then washed with dichloromethane (x 2). These organic extracts were dried (MgSO<sub>4</sub>) then concentrated *in vacuo* to give the sub-title compound. Yield 1.4 g  
MS: ESI (-ve): 244 (M-H)

**d) 4-bromo-2-fluoro-N,N-bis(1-methylethyl)-benzamide**

30 The sub-title compound was prepared by the method of example 18 step a) using 4-bromo-2-fluorobenzoic acid and diisopropylamine.  
MS: ESI (+ve): 304 (M+H)

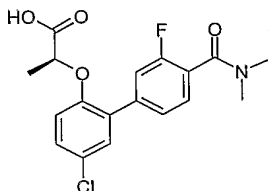
**e) (2*S*)-2-[[4'-[[bis(1-methylethyl)amino]carbonyl]-5-chloro-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

The product of step c) (200 mg), the product of step d) (200 mg), Pd(dppf)Cl<sub>2</sub> (60 mg), sodium carbonate (350 mg) and dioxan (5 ml) were charged to a flask and heated at reflux for 24 h, then cooled to room temp and filtered (hyflo). The filtrate was concentrated *in vacuo*, then purified by reverse phase HPLC to give the title compound. Yield 22 mg

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 13.19 (1H, s), 7.62-7.21 (5H, m), 6.92 (1H, m), 4.97 (1H, q), 3.8-3.46 (2H, m) 1.47(12H, s), and 1.18 (3H, d).

**Example 29**

**(2*S*)-2-[[5-chloro-4'-[(ethylmethylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**



**a) 4-bromo-*N*-ethyl-2-fluoro-*N*-methyl-benzamide**

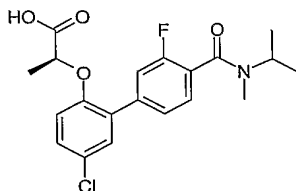
The sub-title compound was prepared by the method of example 18 step a) using 4-bromo-2-fluorobenzoic acid and *N*-methyl-ethanamine.

**b) (2*S*)-2-[[5-chloro-4'-[(ethylmethylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

The title compound was prepared by the method of example 28 step e) using the product of step a) and the product of example 28 step c)

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 7.7 (1H, d), 7.55 (1H, d), 7.4-7.19 (3H, m), 7.02-6.9 (1H, m), 4.62 (1H, q), 3.5-3.2 (2H, q), 2.3 (3H, d), 1.4 (3H, d) and 1.04-1.18 (3H, m).

MS: ESI (-ve): 378 (M-H)

**Example 30****(2S)-2-[[5-chloro-3'-fluoro-4'-[[methyl(1-methylethyl)amino]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid****5 a) 4-bromo-2-fluoro-N-methyl-N-(1-methylethyl)-benzamide**

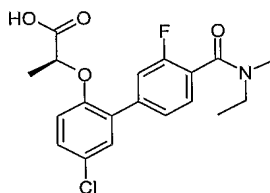
The sub-title compound was prepared by the method of example 18 step a) using 4-bromo-2-fluorobenzoic acid and *N*-methyl-2-propanamine.

**10 b) (2S)-2-[[5-chloro-3'-fluoro-4'-[[methyl(1-methylethyl)amino]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

The title compound was prepared by the method of example 28 step e) using the product of step a) and the product of example 28 step c)

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 7.57-7.31 (5H, m), 7.02(1H, d), 4.9 (1H, q), 3.8 (1H, s, broad), 3.19(2H, s, broad + water), 2.52 (3H, s) and 1.43(1H, d), 1.22-1.16(6H, m)

15 MS: APCI (-ve): 392 (M-H)

**Example 31****(2S)-2-[[5-chloro-4'-[(diethylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid****20 a) 4-bromo-N,N-diethyl-2-fluoro-benzamide**

The sub-title compound was prepared by the method of example 18 step a) using 4-bromo-2-fluorobenzoic acid and *N*-ethyl-ethanamine.

**25 b) (2S)-2-[[5-chloro-4'-[(diethylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

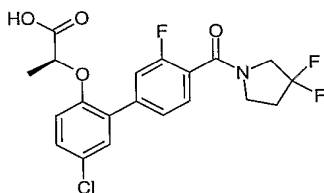
The title compound was prepared by the method of example 28 step e) using the product of step a) and the product of example 28 step c)

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 7.76-7.21 (5H, m), 6.96(1H, s), 4.71 (1H, q, broad), 3.47 (2H, s, broad), 3.19(2H, s, broad), 1.4 (3H, d), 1.16 (3H, t) and 1.04(3H, t).

5 MS: ESI (-ve): 392 (M-H)

### **Example 32**

#### **(2S)-2-[[5-chloro-4'-[(3,3-difluoro-1-pyrrolidinyl)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**



#### **a) 1-(4-bromo-2-fluorobenzoyl)-3,3-difluoro-pyrrolidine**

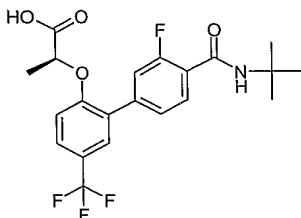
The sub-title compound was prepared by the method of example 18 step a) using 4-bromo-2-fluorobenzoic acid and 3,3-difluoropyrrolidine, hydrochloride salt and triethylamine (2 molar equivalent).

#### **b) (2S)-2-[[5-chloro-4'-[(3,3-difluoro-1-pyrrolidinyl)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

Tetrakis(palladiumtriphenylphosphine) (0) (0.14 g) was added to a mixture of the product of example 28 step c) (0.3 g), toluene (10 ml), 2M sodium carbonate solution (4 ml), ethanol (4 ml) and the product of step a). The reaction mixture was heated at 90°C overnight, then concentrated *in vacuo*. The residue was filtered (hyflo) and the filtrate was purified by reverse phase HPLC to give the title compound. Yield 0.12g.

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 7.7-7.36 (5H, m), 6.9(1H, d), 4.8 (1H, d), 3.9 (1H, t), 3.83-3.66 (1H, m), 3.6-3.45 (2H, m), 2.5 (1H, m), 2.07 (1H, s) and 1.44 (3H, d).

25 MS: ESI (-ve): 426 (M-H)

**Example 33****(2S)-2-[[4'-[[[(1,1-dimethylethyl)amino]carbonyl]-3'-fluoro-5-(trifluoromethyl) [1,1'-biphenyl]-2-yl]oxy]-propanoic acid****a) 4-bromo-N-(1,1-dimethylethyl)-2-fluoro-benzamide**

The sub-title compound was prepared by the method of example 18 step a) and *tertiary*-butyl amine.

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 7.6 (1H, t), 7.4 (1H, dd), 7.3 (1H, dd), 6.57-6.44 (1H, m) and 1.44 (9H, s).

10

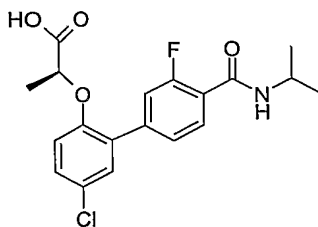
**b) (2S)-2-[[4'-[[[(1,1-dimethylethyl)amino]carbonyl]-3'-fluoro-5-(trifluoromethyl) [1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

The title compound was prepared using the product of step a) and (2S)-2-[2-borono-4-(trifluoromethyl)phenoxy]-propanoic acid [WO2004089885] by the

15 method of example 32 step b).

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 7.9 (1H, s), 7.9-7.53 (5H, m), 7.16 (1H, d), 5.05 (1H, d), 1.47-1.16 (12H, m).

MS: APCI (-ve): 374 (M-H)

**20 Example 34****(2S)-2-[[5-chloro-3'-fluoro-4'-[[[(1-methylethyl)amino]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

**a) 4-bromo-2-fluoro-*N*-(1-methylethyl)-benzamide**

The sub-title compound was prepared by the method of example 18 step a) using 4-bromo-2-fluorobenzoic acid and 2-propanamine.

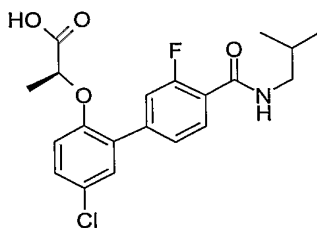
<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 7.97 (1H, t), 7.41 (1H, dd), 7.37 (1H, dd), 6.45 (1H, s), 4.33-4.25 (1H, m),  
 5 1.22 (6H, d),

**b) (2*S*)-2-[[5-chloro-3'-fluoro-4'--[(1-methylethyl)amino]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

The title compound was prepared by the method of example 32 step b) using the  
 10 product of step a) and the product of example 28 step c).

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 8.21 (1H, d), 7.71-7.26 (4H, m), 6.97 (1H, d), 4.92 (1H, d), 4.07 (1H, d), 2.52 (broad peak, contains DMSO and 1H), 1.4 (3H, d) and 1.16 (6H, d),

MS: APCI (+ve): 380 (M+H)

**15 Example 35****(2*S*)-2-[[5-chloro-3'-fluoro-4'--[(2-methylpropyl)amino]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid****a) 4-bromo-2-fluoro-*N*-(2-methylpropyl)-benzamide**

20 The sub-title compound was prepared by the method of example 18 step a) using 4-bromo-2-fluorobenzoic acid and 2-methyl-1-propanamine.

MS: ESI (+ve): 274 (M+H)

**b) (2*S*)-2-[[5-chloro-3'-fluoro-4'--[(2-methylpropyl)amino]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

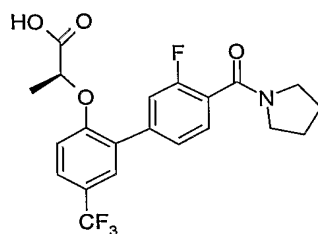
The title compound was prepared by the method of example 32 step b) using the product of step a) and the product of example 28 step c).

$^1\text{H}$  NMR DMSO- $\text{D}_6$ :  $\delta$  8.36 (1H, s), 7.7-7.42 (3H, m), 7.42-7.31 (2H, m), 6.96 (1H, d), 4.82 (1H, q), 3.08 (2H, t), 1.94-1.73 (1H, m), 1.4 (3H, d) and 0.9 (6H, m).

MS: APCI (+ve): 394 (M+H)

### 5 **Example 36**

#### **(2S)-2-[[3'-fluoro-4'-(1-pyrrolidinylcarbonyl)-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**



The title compound was prepared using the product of example 24 part a) and  
10 (2S)-2-[2-borono-4-(trifluoromethyl)phenoxy]-propanoic acid [WO2004089885] by the method of example 32 step b).

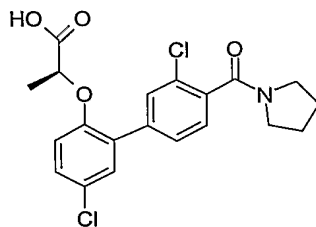
$^1\text{H}$  NMR DMSO- $\text{D}_6$ :  $\delta$  7.88 (1H, d), 7.7-7.51 (3H, m), 7.43 (1H, t), 7.05 (1H, d), 4.54 (1H, q), 3.58-3.06 (4H, m), 1.84 (4H, s) and 1.38 (3H, d).

MS: APCI (-ve): 424 (M-H)

15

### **Example 37**

#### **(2S)-2-[[3',5-dichloro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**



#### 20 **a) (2S)-2-[[3',5-dichloro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-1,1-dimethylethyl ester propanoic acid**

The sub-title compound was prepared by the method of example 1 step e) using the product of example 18 step c).

**b) (2S)-2-[[3',5-dichloro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

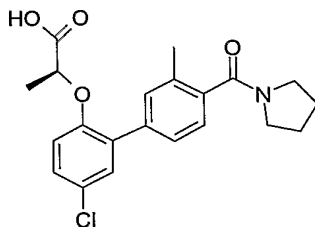
The title compound was prepared by the method of example 25 step b) using the product of step a).

<sup>1</sup>H NMR DMSO-D6: δ 7.82 (1H, s), 7.63 (1H, d), 7.45-7.39 (3H, m), 7.01 (1H, d), 4.96 (1H, q), 3.5 (2H, t), 1.97-1.81 (4H, m) and 1.42 (3H, d).

MS: APCI (-ve): 406 (M-H)

**Example 38**

**10 (2S)-2-[[5-chloro-3'-methyl-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**



**a) 1-[(5'-chloro-2'-hydroxy-3-methyl[1,1'-biphenyl]-4-yl)carbonyl]-pyrrolidine**

The sub-title compound was prepared by the method of example 18 step b) using the product of example 27 step a)

MS: ESI (-ve): 315 (M-H)

**b) (2S)-2-[[5-chloro-3'-methyl-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-1,1-dimethylethyl ester propanoic acid**

The sub-title compound was prepared by the method of example 1 step e) using the product of step a)

MS: ESI (-ve): 442 (M-H)

**c) (2S)-2-[[5-chloro-3'-methyl-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

The product of step b) (0.2 g) was dissolved in dichloromethane (3 ml) and TFA (3 ml) was added and stirred for 2 hours, then concentrated *in vacuo*. Purified by reverse phase HPLC to give the title compound.

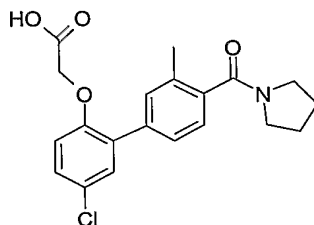


$^1\text{H}$  NMR DMSO- $\text{D}_6$ :  $\delta$  7.54 (2H, s), 7.37-7.21 (3H, m), 6.92 (1H, d), 4.76 (1H, d), 3.5 (2H, s), 3.11 (2H, s), 2.23 (3H, s), 1.98-1.77 (4H, m) and 1.4 (3H, d).

MS: APCI (+ve): 388 (M+H)

5 **Example 39**

**[[5-chloro-3'-methyl-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid**



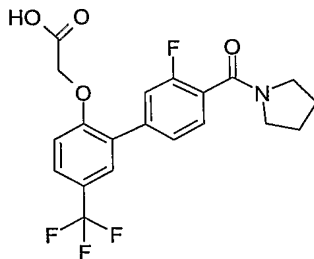
The title compound was prepared by the method of example 18 step d) using the  
10 product of example 38 step a).

$^1\text{H}$  NMR DMSO- $\text{D}_6$ :  $\delta$  7.57-7.18 (5H, m), 7.0 (1H, s), 4.63 (2H, s), 3.48 (2H, s), 3.12 (2H, s), 2.24 (3H, s) and 2.0-1.72 (4H, m).

MS: APCI (+ve): 374 (M+H)

15 **Example 40**

**[[3'-fluoro-4'-(1-pyrrolidinylcarbonyl)-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid**



a) **[[3'-fluoro-4'-(1-pyrrolidinylcarbonyl)-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid-1,1-dimethylethyl ester**  
20

The sub-title compound was prepared by the method of example 32 step b) using the product of example 26 step a) and the product of example 24 step a).

**b) [[3'-fluoro-4'-(1-pyrrolidinylcarbonyl)-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid**

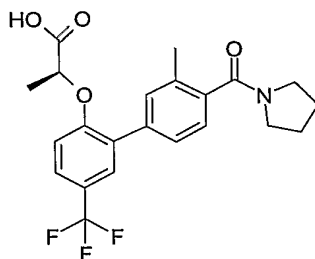
The title compound was prepared by the method of example 38 step c) using the product of step a).

<sup>1</sup>H NMR DMSO-D6: δ 7.73 (1H, dd), 7.70 (1H, d), 7.59 (1H, dd), 7.54-7.46 (2H, m), 7.26 (1H, d), 4.6 (2H, s), 3.49 (2H, t), 3.27 (2H, t), and 1.94-1.8 (4H, m).

MS: APCI (+ve): 412 (M+H)

**Example 41**

**(2S)-2-[[3'-methyl-4'-(1-pyrrolidinylcarbonyl)-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**



The title compound was prepared using the product of example 27 step a) and (2S)-2-[2-borono-4-(trifluoromethyl)phenoxy]-propanoic acid [WO2004089885] by the

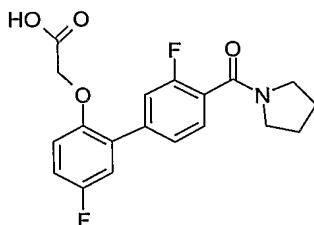
method of example 32 step b).

<sup>1</sup>H NMR DMSO-D6: δ 7.78-7.43 (4H, m), 7.23 (1H, d), 7.06 (1H, d), 5.04 (1H, d), 3.37 (2H, d), 3.08 (2H, m), 2.28 (3H, s), 1.96-1.72 (4H, m) and 1.45 (3H, d).

MS: APCI (+ve): 422 (M+H)

**Example 42**

**[[3',5-difluoro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid**



**a) 3,5'-difluoro-2'-methoxy-[1,1'-biphenyl]-4-carboxylic acid**

5-fluoro-2-methoxyboronic acid (1 g), 4-bromo-2-fluorobenzoic acid (1.29 g), tetrakis palladiumtriphenylphosphine (0) (0.6 g), toluene (40 ml), ethanol (16 ml) and 2M sodium carbonate (10 ml) were charged to a flask and heated at reflux overnight. The mixture was concentrated *in vacuo* then diluted with water and ethyl acetate. The aqueous layer was separated and acidified with 1N HCl, then extracted with ethyl acetate. The latter ethyl acetate layers were dried (MgSO<sub>4</sub>) and concentrated *in vacuo* to give the sub-title compound as a beige solid. Yield 1.45 g.

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 8.08 (1H, t), 7.4 (2H, d), 7.11-7.04 (2H, m), 6.96-6.9 (1H, m), 3.81 (3H, s).

MS: ESI (-ve): 306 (M-H)

**b) 1-[(3,5'-difluoro-2'-methoxy[1,1'-biphenyl]-4-yl)carbonyl]-pyrrolidine**

The sub-title compound was prepared by the method of example 18 step a) using the product of step a) and pyrrolidine.

MS: ESI (+ve): 318 (M+H)

**c) 1-[(3,5'-difluoro-2'-hydroxy[1,1'-biphenyl]-4-yl)carbonyl]-pyrrolidine**

The sub-title compound was prepared by the method of example 18 step c) using the product of step b).

MS: ESI (-ve): 304 (M-H)

**d) [[3',5'-difluoro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid**

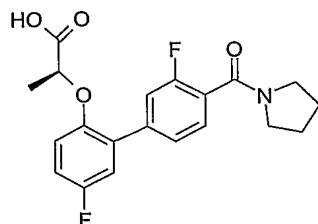
The title compound was prepared by the method of example 18 step d) using the product of step c).

MS: ESI (-ve): 362 (M-H)

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 7.8-6.6 (6H, m), 4.49 (2H, s), 3.6-3.04 (4H, m) and 2-1.67 (4H, m).

**Example 43**

**(2S)-2-[[3',5-difluoro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**



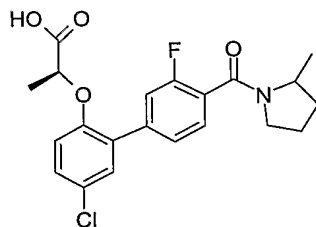
5 The title compound was prepared by the methods of example 1 step e) and example 38 step c) using the product of example 42 step c).

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 7.76 (1H, d), 7.573 (1H, d), 7.39 (1H, t), 7.24 (1H, d), 7.17-7.01 (1H, m), 6.95-6.84 (1H, m), 4.67 (1H, m), 3.47 (2H, t), 3.4-3.1 (4H, m), 1.89-1.84 (2H, m) and 1.38 (3H, d).

10 MS: APCI (-ve): 374 (M-H)

**Example 44**

**(2S)-2-[[5-chloro-3'-fluoro-4'-(2-methyl-1-pyrrolidinyl)carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid**



15

The title compound was prepared by the methods of example 32 step a) and example 32 step b) using the products of example 28 step c) and 2-methylpyrrolidine.

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 7.74-7.65 (1H, m), 7.59-7.5 (1H, m), 7.42-7.31 (3H, m), 6.92 (1H, d), 4.7 (1H, q), 4.21-4.08 (1H, m), 3.6-3.5 (1H, m), 3.4-3.2 (1H, m), 2.1-1.7 (4H, m), 1.4 (3H, d), 1.23 (3H, d).

20

MS: APCI (-ve): 404 (M-H)

The compound was further purified by chiral HPLC to give:-

**Example 45**

**(2S)-2-[[5-chloro-3'-fluoro-4'-[(2S)-2-methyl-1-pyrrolidinyl]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

MS: APCI (-ve): 404 (M-H)

5 and

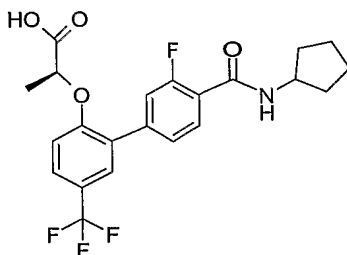
**Example 46**

**(2S)-2-[[5-chloro-3'-fluoro-4'-[(2R)-2-methyl-1-pyrrolidinyl]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

10 MS: APCI (-ve): 404 (M-H)

**Example 47**

**(2S)-2-[[4'-[(cyclopentylamino)carbonyl]-3'-fluoro-5-(trifluoromethyl)][1,1'-biphenyl]-2-yl]oxy]-propanoic acid**



15

**a) 4-bromo-N-cyclopentyl-2-fluoro-benzamide**

The sub-title compound was prepared by the method of example 18 step a) using 4-bromo-2-fluorobenzoic acid and cyclopentanamine.

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 7.98 (1H, t), 7.4 (1H, d), 7.36-7.12 (1H, m), 6.65-6.43 (1H, m), 4.4 (1H, qd), 2.19-2 (2H, m), 1.8-1.43 (6H, m).

20

**b) (2S)-2-[[4'-[(cyclopentylamino)carbonyl]-3'-fluoro-5-(trifluoromethyl)][1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

The title compound was prepared using the product of step a) and

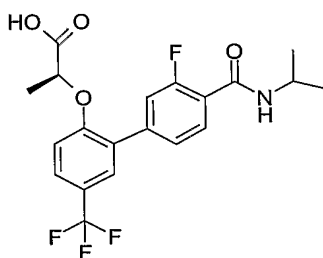
25 (2S)-2-[2-borono-4-(trifluoromethyl)phenoxy]-propanoic acid [WO2004089885] by the method of example 32 step b).

$^1\text{H}$  NMR DMSO- $\text{D}_6$ :  $\delta$  8.31(1H, d), 7.78-7.43 (5H, m), 7.17 (1H, d), 5.03 (1H, q), 4.21 (1H, q), 1.9-1.8 (2H, m), 1.78-1.63 (2H, m) and 1.78-1.4 (7H, m).

MS: APCI (-ve): 438 (M-H)

#### 5 **Example 48**

**(2S)-2-[[3'-fluoro-4'-[(1-methylethyl)amino]carbonyl]-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**



The title compound was prepared using the product of example 34 step a) and

10 (2S)-2-[2-borono-4-(trifluoromethyl)phenoxy]-propanoic acid [WO2004089885] by the method of example 32 step b).

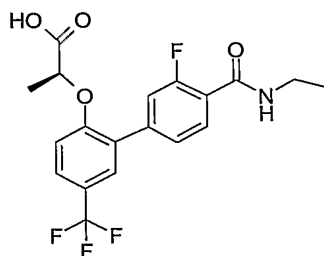
$^1\text{H}$  NMR DMSO- $\text{D}_6$ :  $\delta$  8.19 (1H, d), 7.73-7.54 (5H, m), 7.11 (1H, d), 4.83 (1H, q), 4.06 (1H, sept), 1.4 (3H, d), and 1.16 (6H, d).

MS: APCI (-ve): 412 (M-H)

15

#### **Example 49**

**(2S)-2-[[4'-[(ethylamino)carbonyl]-3'-fluoro-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**



#### 20 **a) 4-bromo-N-ethyl-2-fluoro-benzamide**

The sub-title compound was prepared by the method of example 18 step a) using 4-bromo-2-fluorobenzoic acid, ethylamine hydrochloride and triethylamine.

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 8.01 (1H, t), 7.41 (1H, d), 7.31 (1H, d), 6.62 (1H, s), 3.51 (2H, q) and 1.26 (3H, t).

**b) (2S)-2-[[4'-[(ethylamino)carbonyl]-3'-fluoro-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

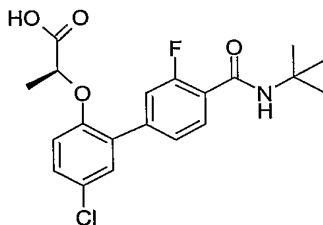
The title compound was prepared using the product of step a) and (2S)-2-[2-borono-4-(trifluoromethyl)phenoxy]-propanoic acid [WO2004089885] by the method of example 32 step b).

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 8.35 (1H, t), 7.73-7.5 (5H, m), 7.14 (1H, d), 5.03 (1H, m), 3.3 (2H, q), 1.43 (3H, d), and 1.1 (3H, t).

MS: APCI (+ve): 400 (M+H)

**Example 50**

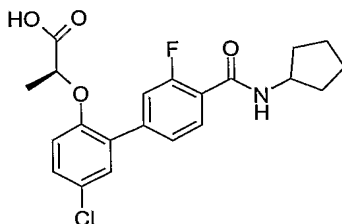
**(2S)-2-[[5-chloro-4'-[(1,1-dimethylethyl)amino]carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**



The title compound was prepared using the product of example 33 step a) and the product of example 28 step c) by the method of example 32 step b).

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 7.89 (1H, s), 7.57-7.38 (5H, m), 6.99 (1H, d), 4.98 (1H, q), 1.43 (3H, d) and 1.39 (9H, s)

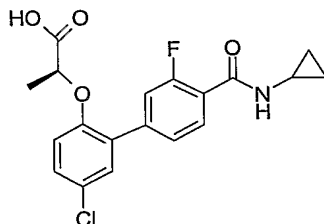
MS: APCI (-ve): 392 (M-H)

**Example 51****(2S)-2-[[5-chloro-4'-[(cyclopentylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

5 The title compound was prepared by the method of example 32 step b) using the products of example 28 step c) and example 47 step a).

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 13.18 (1H, s), 8.32 (1H, d), 7.6-7.39 (5H, m), 7.01 (1H, d), 4.98 (1H, q), 4.24-4.19 (1H, m), 1.98-1.82 (2H, m), 1.81-1.59 (2H, m) and 1.78-1.41 (7H, m).

MS: APCI (-ve): 404 (M-H)

**Example 52****(2S)-2-[[5-chloro-4'-[(cyclopropylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid****a) 4-bromo-N-cyclopropyl-2-fluoro-benzamide**

The sub-title compound was prepared by the method of example 18 step a) using ) 4-bromo-2-fluorobenzoic acid, and cyclopropylamine.

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 8.02 (1H, t), 7.42 (1H, d), 7.29 (1H, dd), 6.73-6.71 (1H, m), 2.96-2.94 (1H, m), 1.63-1.6 (2H, m) and 0.87-0.82 (2H, m).

**b) (2S)-2-[[5-chloro-4'-[(cyclopropylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

The title compound was prepared by the method of example 32 step b) using the products of example 28 step c) and step a).



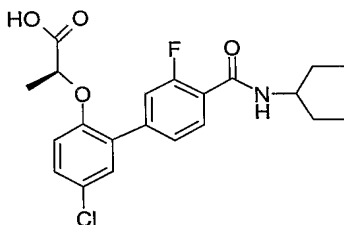
$^1\text{H}$  NMR DMSO- $\text{D}_6$ :  $\delta$  8.40 (1H, d), 7.60 - 7.55 (2H, m), 7.50 (1H, dd), 7.42 - 7.38 (2H, m), 7.01 (1H, d), 4.98 (1H, q), 2.86 (1H, dsxtet), 1.44 (3H, d), 0.73 - 0.68 (2H, m), 0.58 - 0.53 (2H, m).

MS: APCI (-ve): 376 (M-H)

5

### **Example 53**

**(2S)-2-[[5-chloro-4'-[[[(1-ethylpropyl)amino]carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**



#### 10 **a) 4-bromo-N-(1-ethylpropyl)-2-fluoro-benzamide**

The sub-title compound was prepared by the method of example 18 step a) using 4-bromo-2-fluorobenzoic acid and 3-pentanamine.

$^1\text{H}$  NMR  $\text{CDCl}_3$ :  $\delta$  7.97 (1H, t), 7.42 (1H, dd), 7.31 (1H, dd), 6.4-6.33 (1H, m), 4.06-4.0 (1H, m), 1.7-1.62 (2H, m), 1.51-1.42 (2H, m) and 0.97 (6H, t).

15

#### **b) 5'-chloro-N-(1-ethylpropyl)-3-fluoro-2'-methoxy-[1,1'-biphenyl]-4-carboxamide**

The sub-title compound was prepared by the method of example 18 step b) using the product of step a) and 4-chloro-2-methoxy boronic acid.

MS: ESI (+ve): 350 (M+H)

20

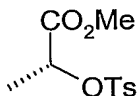
#### **c) 5'-chloro-N-(1-ethylpropyl)-3-fluoro-2'-hydroxy-[1,1'-biphenyl]-4-carboxamide**

The sub-title compound was prepared by the method of example 18 step c) using the product of step b).

MS: ESI (-ve): 334 (M-H)

25

#### **d) (2R)- 2-(4-methylphenoxy)-propanoic acid, methyl ester**



A solution of methyl (*R*)-(+)-lactate (6.66 g) in acetonitrile (33 ml) was cooled to 5°C and triethylamine (9.8 ml) added followed by trimethylamine hydrochloride (0.62 g). A separate solution of *p*-toluenesulfonyl chloride (11.6 g) in acetonitrile (33 ml) was added dropwise over 20 mins maintaining the temperature below 5°C. The reaction mixture was  
5 filtered and concentrated. Diethyl ether and water were added and the organic fraction dried (MgSO<sub>4</sub>) and concentrated *in vacuo* to give the sub-title compound as a yellow oil (13.71 g).

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 7.82 (2H, d), 7.35 (2H, d), 4.95 (1H, q), 3.67 (3H, s), 2.45 (3H, s), 1.51 (3H, d).

10

**e) (2*S*)-2-[[5-chloro-4'-[(1-ethylpropyl)amino]carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

The product of step c) (300 mg), the product of step d) (219 mg) and potassium carbonate (135 mg) in acetonitrile (10 ml) were charged to a flask and stirred at 50°C for 16

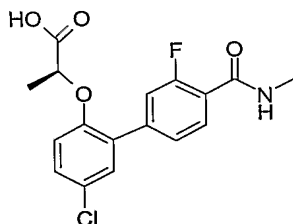
15 h. The reaction mixture was cooled, diluted with water (20 ml) and extracted with diethyl ether (3 x 10 ml). The organic fractions were washed with brine, dried (MgSO<sub>4</sub>) and concentrated *in vacuo*. The resulting yellow oil was dissolved in a 1:1 mixture of THF/methanol (10 ml) and 1M NaOH added (1.1 ml). The mixture was stirred at room temperature for 4 h and then concentrated *in vacuo*. The residue was purified by RPHPLC to  
20 give the title compound as a white solid (175 mg).

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 8.02 (1H, d), 7.75 (1H, d), 7.59-7.48 (2H, m), 7.31 (2H, td), 6.93 (1H, d), 4.59 (1H, q), 3.75 (1H, quintet), 1.59-1.37 (4H, m), 1.34 (3H, d), 0.89 (6H, t).

MS: APCI (-ve): 406 (M-H)

25

30

**Example 54****(2S)-2-[[5-chloro-3'-fluoro-4'-[(methylamino)carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid****5 a) 4-bromo-2-fluoro-N-methyl-benzamide**

The sub-title compound was prepared by the method of example 18 step a) using 4-bromo-2-fluorobenzoic acid and methylamine hydrochloride.

$^1\text{H}$  NMR  $\text{CDCl}_3$ :  $\delta$  8.00 (1H, t), 7.42 (1H, dd), 7.32 (1H, dd), 6.66 (1H, s), 3.03 (3H, dd).

**10 b) 5'-chloro-3-fluoro-2'-methoxy-N-methyl-[1,1'-biphenyl]-4-carboxamide**

The sub-title compound was prepared by the method of example 18 step b) using the product of step a) and 4-chloro-2-methoxy boronic acid.

MS: ESI (+ve): 294 (M+H)

**15 c) 5'-chloro-3-fluoro-2'-hydroxy-N-methyl-[1,1'-biphenyl]-4-carboxamide**

The sub-title compound was prepared by the method of example 18 step c) using the product of step b).

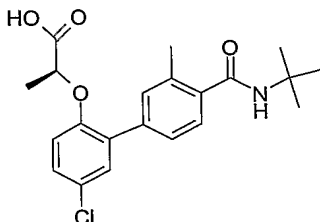
MS: ESI (-ve): 278 (M-H)

**20 d) (2S)-2-[[5-chloro-3'-fluoro-4'-[(methylamino)carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

The title compound was prepared by the method of example 53 step e) using the product of step c). Purification by RPHPLC gave a white solid (170 mg).

$^1\text{H}$  NMR  $\text{DMSO}-d_6$ :  $\delta$  8.27 (1H, s), 7.85 (1H, d), 7.70-7.51 (2H, m), 7.34 (1H, d), 7.28 (1H, dd), 6.91 (1H, d), 4.50 (1H, q), 2.78 (3H, d), 1.33 (3H, d).

MS: APCI (-ve): 350 (M-H)

**Example 55****(2S)-2-[[5-chloro-4'-[[[(1,1-dimethylethyl)amino]carbonyl]-3'-methyl[1,1'-biphenyl]-2-yl]oxy]-propanoic acid****a) 4-bromo-*N*-(1,1-dimethylethyl)-2-methyl-benzamide**

The sub-title compound was prepared by the method of example 18 step a) using 4-bromo-2-methylbenzoic acid and tertiarybutylamine.

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 7.36 (1H, d), 7.32 (1H, dd), 7.18 (1H, d), 5.50 (1H, s), 2.40 (3H, s), 1.46 (9H, s).

**b) 5'-chloro-*N*-(1,1-dimethylethyl)-2'-methoxy-3-methyl-[1,1'-biphenyl]-4-carboxamide**

The sub-title compound was prepared by the methods of example 18 step b) using the product of step a) and 4-chloro-2-methoxy boronic acid.

MS: ESI (+ve): 332.0 (M+H)

**c) 5'-chloro-*N*-(1,1-dimethylethyl)-2'-hydroxy-3-methyl-[1,1'-biphenyl]-4-carboxamide**

The sub-title compound was prepared by the method of example 18 step c) using the product of step b).

MS: ESI (-ve): 316.0 (M-H)

**d) (2S)-2-[[5-chloro-4'-[[[(1,1-dimethylethyl)amino]carbonyl]-3'-methyl[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

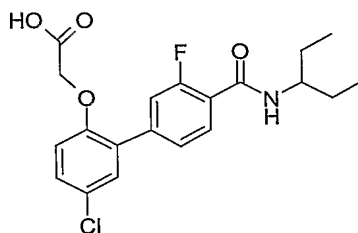
The title compound was prepared by the method of example 53 step e) using the product of step c). Purification by RPHPLC gave a white solid (230 mg).

<sup>1</sup>H NMR DMSO-D<sub>6</sub>: δ 7.86 (1H, s), 7.56 (1H, d), 7.54 (1H, s), 7.25-7.19 (3H, m), 6.93-6.88 (1H, m), 4.39 (1H, m), 2.33 (3H, s), 1.36 (9H, s), 1.30 (3H, d).

MS: APCI (-ve): 388 (M-H)

**Example 56**

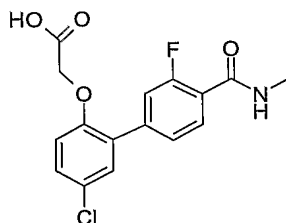
**[[5-chloro-4'-[[[(1-ethylpropyl)amino]carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-acetic acid**



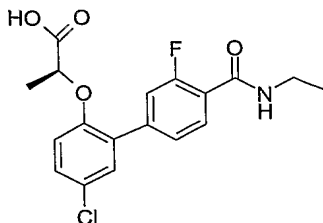
The title compound was prepared by the method of example 18 step d) using the  
5 product of example 53 step c). Purification by RPHPLC gave a white solid (81 mg).  
<sup>1</sup>H NMR DMSO-D6: δ 8.06 (1H, d), 7.66-7.48 (3H, m), 7.42-7.35 (2H, m), 7.04 (1H, d), 4.60  
(2H, s), 3.85-3.69 (1H, m), 1.64-1.38 (4H, m), 0.91 (6H, t).  
MS: APCI (-ve): 392 (M-H)

10 **Example 57**

**[[5-chloro-3'-fluoro-4'-[(methylamino)carbonyl][1,1'-biphenyl]-2-yl]oxy]-acetic acid**



The title compound was prepared by the method of example 18 step d) using the  
product of example 54 step c). Purification by trituration from diethyl ether/ isohexane gave a  
15 white solid (320 mg).  
<sup>1</sup>H NMR DMSO-D6: δ 13.11 (1H, s), 8.27 (1H, s), 7.65 (1H, t), 7.56 (1H, dd), 7.48 (1H, dd),  
7.44-7.38 (2H, m), 7.09 (1H, d), 4.78 (2H, s), 3.79 (3H, d).  
MS: APCI (-ve): 336 (M-H)

**Example 58****(2S)-2-[[5-chloro-4'-[( ethylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**5 **a) 5'-chloro-N-ethyl-3-fluoro-2'-methoxy-[1,1'-biphenyl]-4-carboxamide**

The sub-title compound was prepared by the method of example 18 step a) using the product of example 21 step a) and ethylamine hydrochloride.

MS: ESI (+ve): 310 (M+H)

10 **b) 5'-chloro-N-ethyl-3-fluoro-2'-hydroxy-[1,1'-biphenyl]-4-carboxamide**

The sub-title compound was prepared by the method of example 18 step c) using the product of step a).

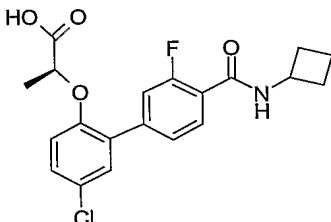
MS: ESI (-ve): 294 (M-H)

15 **c) (2S)-2-[[5-chloro-4'-[( ethylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

The title compound was prepared by the methods of example 1 step e) and example 38 step c) using the product of step b). Purification by RPHPLC gave a white solid (28 mg).

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 7.93 (1H, t), 7.37 (1H, dd), 7.3 (1H, d), 7.23 (1H, d), 7.14 (1H, d), 6.79 (2H, m), 4.55 (1H, q), 3.48 (2H, m), 1.41 (3H, d) and 1.26 (3H, t).

MS: APCI (-ve): 364 (M-H)

**Example 59****(2S)-2-[[5-chloro-4'-[(cyclobutylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

5

**a) 5'-chloro-N-cyclobutyl-3-fluoro-2'-methoxy-[1,1'-biphenyl]-4-carboxamide**

The sub-title compound was prepared by the method of example 18 step a) using the product of example 21 step a) and cyclobutanamine.

MS: ESI (+ve): 336 (M+H)

10

**b) 5'-chloro-N-cyclobutyl-3-fluoro-2'-hydroxy-[1,1'-biphenyl]-4-carboxamide**

The sub-title compound was prepared by the method of example 18 step c) using the product of step a).

MS: ESI (-ve): 320 (M-H)

15

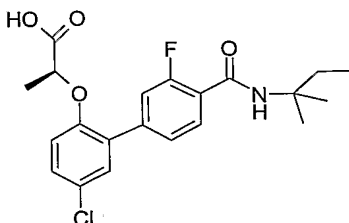
**c) (2S)-2-[[5-chloro-4'-[( ethylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

The title compound was prepared by the methods of example 1 step e) and example 38 step c) using the product of step b). Purification by RPHPLC gave a white solid (27 mg).

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 7.92 (1H, t), 7.35 (2H, m), 7.12 (1H, d), 6.99 (2H, m), 6.74 (1H, d), 4.95 (1H, m), 4.56 (1H, m), 2.4 (2H, s (broad)), 1.97 (2H, t), 1.77 (2H, s (broad)) and 1.41 (3H, d).

MS: APCI (+ve): 392 (M+H)

25

**Example 60****(2S)-2-[[5-chloro-4'-[(1,1-dimethylpropyl)amino]carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid****5 a) 5'-chloro-N-(1,1-dimethylpropyl)-3-fluoro-2'-methoxy-[1,1'-biphenyl]-4-carboxamide**

The sub-title compound was prepared by the method of example 18 step a) using the product of example 21 step a) and tert-amylamine.

MS: ESI (+ve): 352 (M+H)

**10 b) 5'-chloro-N-(1,1-dimethylpropyl)-3-fluoro-2'-hydroxy-[1,1'-biphenyl]-4-carboxamide**

The sub-title compound was prepared by the method of example 18 step c) using the product of step a).

MS: ESI (-ve): 334 (M-H)

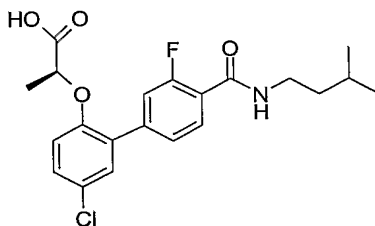
**15 c) (2S)-2-[[5-chloro-4'-[(1,1-dimethylpropyl)amino]carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

The title compound was prepared by the method of example 53 step e) using the product of step b). Purification by RPHPLC gave a white solid (220 mg).

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 7.86 (1H, t), 7.35 (1H, d), 7.26 (1H, t), 7.18 (1H, d), 7.00 (1H, d), 6.66 (1H, d), 6.53 (1H, d), 4.41 (1H, d), 1.78 (2H, q), 1.38 (6H, s), 1.30 (3H, d), 0.89 (3H, t).

MS: APCI (-ve): 406 (M-H)



**Example 61****(2*S*)-2-[[5-chloro-3'-fluoro-4'-[[3-methylbutyl)amino]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid****a) 5'-chloro-3-fluoro-2'-methoxy-*N*-(3-methylbutyl)-[1,1'-biphenyl]-4-carboxamide**

The sub-title compound was prepared by the method of example 18 step a) using the product of example 21 step a) and isoamylamine.

MS: ESI (+ve): 352 (M+H)

**b) 5'-chloro-3-fluoro-2'-hydroxy-*N*-(3-methylbutyl)-[1,1'-biphenyl]-4-carboxamide**

The sub-title compound was prepared by the method of example 18 step c) using the product of step a).

MS: ESI (-ve): 334 (M-H)

**c) (2*S*)-2-[[5-chloro-3'-fluoro-4'-[[3-methylbutyl)amino]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid**

The title compound was prepared by the method of example 53 step e) using the product of step b).

<sup>1</sup>H NMR CDCl<sub>3</sub>: δ 7.75 (1H, t), 7.32 (1H, d), 7.23 (1H, d), 7.10 (1H, s), 6.90 (1H, d), 6.83 (1H, t), 6.61 (1H, d), 4.28 (1H, d), 3.37 (2H, d), 1.62 (1H, t), 1.44 (2H, d), 1.17 (3H, d), 0.90 (6H, d).

MS: APCI (-ve): 406 (M-H)

**Pharmacological Data**Ligand Binding Assay

[<sup>3</sup>H]PGD<sub>2</sub> was purchased from Perkin Elmer Life Sciences with a specific activity of  
5 100-210Ci/mmol. All other chemicals were of analytical grade.

HEK cells expressing rhCRTh2 / Gα16 were routinely maintained in DMEM containing 10% Foetal Bovine Serum (HyClone), 1mg/ml geneticin, 2mM L-glutamine and 1% non-essential amino acids. For the preparation of membranes, the adherent transfected HEK cells were grown to confluence in two layer tissue culture factories (Fisher, catalogue  
10 number TKT-170-070E). Maximal levels of receptor expression were induced by addition of 500mM sodium butyrate for the last 18 hours of culture. The adherent cells were washed once with phosphate buffered saline (PBS, 50ml per cell factory) and detached by the addition of 50ml per cell factory of ice-cold membrane homogenisation buffer [20mM HEPES (pH 7.4), 0.1mM dithiothreitol, 1mM EDTA, 0.1mM phenyl methyl sulphonyl fluoride and 100µg/ml  
15 bacitracin]. Cells were pelleted by centrifugation at 220xg for 10 minutes at 4°C, re-suspended in half the original volume of fresh membrane homogenisation buffer and disrupted using a Polytron homogeniser for 2 x 20 second bursts keeping the tube in ice at all times. Unbroken cells were removed by centrifugation at 220xg for 10 minutes at 4°C and the membrane fraction pelleted by centrifugation at 90000xg for 30 minutes at 4°C. The final  
20 pellet was re-suspended in 4 ml of membrane homogenisation buffer per cell factory used and the protein content determined. Membranes were stored at -80°C in suitable aliquots.

All assays were performed in Corning clear bottomed, white 96-well NBS plates (Fisher). Prior to assay, the HEK cells membranes containing CRTh2 were coated onto SPA PVT WGA beads (Amersham). For coating membranes were incubated with beads at  
25 typically 25µg membrane protein per mg beads at 4°C with constant agitation overnight. (The optimum coating concentrations were determined for each batch of membranes) The beads were pelleted by centrifugation (800xg for 7minutes at 4°C), washed once with assay buffer (50mM HEPES pH 7.4 containing 5mM magnesium chloride) and finally re-suspended in assay buffer at a bead concentration of 10mg/ml.

30 Each assay contained 20µl of 6.25nM [<sup>3</sup>H]PGD<sub>2</sub>, 20µl membrane saturated SPA beads both in assay buffer and 10µl of compound solution or 13,14-dihydro-15-keto prostaglandin D<sub>2</sub> (DK-PGD<sub>2</sub>, for determination of non-specific binding, Cayman chemical company).

Compounds and DK-PGD<sub>2</sub> were dissolved in DMSO and diluted in the same solvent to 100x the required final concentration. Assay buffer was added to give a final concentration of 10% DMSO (compounds were now at 10x the required final concentration) and this was the solution added to the assay plate. The assay plate was incubated at room temperature for 5 2 hours and counted on a Wallac Microbeta liquid scintillation counter (1 minute per well).

Compounds of formula (I) have an IC<sub>50</sub> value of less than (<) 10µM.

Specifically example 5 has a pIC<sub>50</sub> value of 8.75, example 11 has a pIC<sub>50</sub> value of 7.45 and example 13 has a pIC<sub>50</sub> of 8.15.

#### Shape Change Assay

10 DK-PGD<sub>2</sub> [13,14-dihydro-15-keto Prostaglandin D<sub>2</sub>] was obtained from Cayman Chemical (Michigan, USA). OptilyseB was from Immunotech (Marseille, France). All other chemical reagents were of analytical grade from Fisher Scientific (Loughborough, UK) or Sigma (Poole, UK).

Human blood was taken by venipuncture from healthy volunteers into Monovette 15 tubes (Sarstedt) containing heparin as anticoagulant. The assays were carried out in deep 96-well polypropylene plate. The blood (90 µL) is incubated with tested compounds (10 µL) during 4 min at 37°C. Cells were fixed by the addition of 100 µL of optilyse B (Immunotech) followed by incubation at room temperature for 10 min. Next, red blood cells were lysed by the addition of 1 mL of water and further incubation at room temperature for 45 min. The 20 plate was centrifuged for 5 min at 375 x g, the supernatant was discarded and cells were resuspended in 400 µL of assay buffer (Dulbecco's PBS without Ca<sup>2+</sup> and Mg<sup>2+</sup> supplemented with 10 mM HEPES, 10 mM glucose and 0.1% BSA; pH 7.4). The fixed cells were transferred to tubes suitable for use with the flow cytometer.

Shape change was determined using a Coulter FC500 flow cytometer, by measuring 25 the ability of these cells to scatter light when illuminated. By gating the granulocyte region on the basis of their FS/SS profile, FL-2 was plotted against FL-1 identifying two populations of cells: neutrophils with low auto-fluorescence and eosinophils that showed higher natural autofluorescence. The eosinophil population is gated and changes in the median value in FS are recorded.

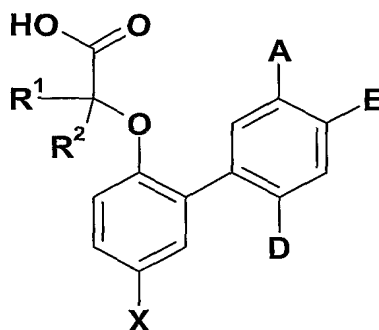
30 Compounds were tested at final concentrations of 1 and 10 µM. These were dissolved in DMSO to give a 10 mM solution. Further dilutions were performed in 96-well

polypropylene plates in assay buffer to give a 100  $\mu$ M solution containing 1%DMSO. An additional 1 in 10 dilution was made in assay buffer containing 1% DMSO. Both these solutions were diluted 1 in 10 into the assay mixture to give a final DMSO concentration of 0.1% (v/v). Concentration response curves for DK-PGD<sub>2</sub> were constructed as a control in  
5 each experiment. The efficacy of tested compounds was expressed as a fraction of the maximum response to PGD<sub>2</sub>.

These compounds were considered antagonists when their efficacy ratio was lower than 0.25.

## Claims

1. A compound of formula (I) or a pharmaceutically acceptable salt thereof:



(I)

in which:

X is halogen, or C<sub>1-2</sub> alkyl which is substituted by one or more halogen atoms;

A and E are independently selected from halogen, SO<sub>2</sub>NR<sup>3</sup>R<sup>4</sup>, SO<sub>n</sub>R<sup>5</sup> (n=1 or 2), CONR<sup>3</sup>R<sup>4</sup>, or C<sub>1-3</sub> alkyl which can be optionally substituted by one or more halogen atoms;

D is hydrogen or fluorine;

R<sup>1</sup> and R<sup>2</sup> independently represent a hydrogen atom, or a C<sub>1-3</sub>alkyl group;

or

R<sup>1</sup> and R<sup>2</sup> together can form a 3-8 membered ring optionally containing one or more atoms selected from O, S, NR<sup>6</sup> and itself optionally substituted by one or more C<sub>1</sub>-C<sub>3</sub> alkyl;

R<sup>3</sup> and R<sup>4</sup> independently represent hydrogen, C<sub>3</sub>-C<sub>7</sub> cycloalkyl or C<sub>1-6</sub>alkyl, the latter two groups being optionally substituted by one or more substituents independently selected from halogen, C<sub>3</sub>-C<sub>7</sub> cycloalkyl, OR<sup>6</sup> and NR<sup>7</sup>R<sup>8</sup>;

or

R<sup>3</sup> and R<sup>4</sup> together with the nitrogen atom to which they are attached can form a 3-8 membered saturated heterocyclic ring optionally containing one or more atoms selected from O, S(O)<sub>n</sub> (where n = 0,1 or 2), NR<sup>8</sup>, and itself optionally substituted by halogen or C<sub>1-3</sub> alkyl;

R<sup>5</sup> is C<sub>1</sub>-C<sub>6</sub> alkyl or C<sub>3-7</sub> cycloalkyl, which may be optionally substituted by halogen atoms;

$R^6$  is hydrogen or  $C_1$ - $C_6$  alkyl;

$R^7$  and  $R^8$  independently represent hydrogen,  $C_1$ - $C_6$  alkyl or  $C_3$ - $C_7$  cycloalkyl

or

$R^7$  and  $R^8$  together with the nitrogen atom to which they are attached can form a 3-8  
5 membered saturated heterocyclic ring as defined above for  $R^3$  and  $R^4$ .

2. A compound according to claim 1 in which X is chlorine, fluorine or trifluoromethyl.

3. A compound according to claims 1 to 2 above in which A and E independently  
10 represent trifluoromethyl,  $C_1$ - $C_3$ alkyl, halogen,  $SOR^5$ ,  $SO_2R^5$ ,  $CONR^3R^4$  or  $SO_2NR^3R^4$ .

4. A compound according to any one of claims 1 to 3 in which D is hydrogen or fluorine;

5. A compound according to any of claims 1 to 4 in which  $R^1$  and  $R^2$  are both hydrogen.  
15

6. A compound according to any one of claims 1 to 4 in which one of  $R^1$  and  $R^2$  is hydrogen and the other is methyl.

7. A compound according to any one of claims 1 to 6 selected from:

20 (2*S*)-2-[[4'-(methylsulfonyl)-3',5-bis(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

[[3',5-Dichloro-4'-(methylsulfonyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid;

[[3',5-Dichloro-4'-(methylsulfonyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid;

(2*S*)-2-[[3',5-Dichloro-4'-(methylsulfonyl)[1,1'-biphenyl]-2-yl]oxy]propanoic acid;

25 (2*S*)-2-[4-chloro-2-[2,5-difluoro-4-(4-morpholinylsulfonyl)phenoxy]phenoxy]-propanoic acid;

[[3'-Fluoro-4'-[(1-methylethyl)sulfonyl]-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid;

[[5-Chloro-4'-(methylsulfonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

30 [[5-Fluoro-4'-(methylsulfonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

[[4'-(Ethylsulfonyl)-3',5-bis(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid;

(2*S*)- 2-[[4'-(Ethylsulfonyl)-3',5-bis(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]propanoic acid;

[[5-Chloro-4'-(4-morpholinylsulfonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid;

(2S)-2-[[5-Chloro-4'-(4-morpholinylsulfonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]propanoic acid;

5 [[5-Chloro-4'-(1-pyrrolidinylcarbonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

(2S)-2-[[5-Chloro-4'-(1-pyrrolidinylcarbonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]propanoic acid;

[[5-Chloro-4'-(ethylsulfonyl)-3'-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]acetic acid;

10 (2S)- 2-[[5-Chloro-4'-(methylsulfonyl)-(3'-trifluoromethyl)-[1,1'-biphenyl]-2-yl]oxy]propanoic acid;

(2S)- 2-[[5-Chloro-3'-fluoro-4'-(methylsulfonyl)[1,1'-biphenyl]-2-yl]oxy]propanoic acid;

[[3',5-dichloro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

[[3',5-dichloro-4'-(4-morpholinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

15 [[4'-(1-azetidylcarbonyl)-3',5-dichloro[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

[[3',5-dichloro-4'-[(2R,6S)-2,6-dimethyl-1-piperidinyl]carbonyl][1,1'-biphenyl]-2-yl]oxy]-acetic acid;

[[3',5-dichloro-4'-[(2-methyl-1-pyrrolidinyl)carbonyl][1,1'-biphenyl]-2-yl]oxy]-acetic acid;

[[3',5-dichloro-4'-(2-isoxazolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

20 [[5-chloro-3'-fluoro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

(2S)-2-[[5-chloro-3'-fluoro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

[[3'-methyl-4'-(1-piperidinylcarbonyl)-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

25 [[3'-methyl-4'-(1-pyrrolidinylcarbonyl)-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

(2S)-2-[[4'-[[bis(1-methylethyl)amino]carbonyl]-5-chloro-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2S)-2-[[5-chloro-4'-(ethylmethylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-

30 propanoic acid;

(2S)-2-[[5-chloro-3'-fluoro-4'-[[methyl(1-methylethyl)amino]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2S)-2-[[5-chloro-4'-[(diethylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2S)-2-[[5-chloro-4'-[(3,3-difluoro-1-pyrrolidinyl)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

5 (2S)-2-[[4'-[[[(1,1-dimethylethyl)amino]carbonyl]-3'-fluoro-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2S)-2-[[5-chloro-3'-fluoro-4'-[(1-methylethyl)amino]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2S)-2-[[5-chloro-3'-fluoro-4'-[(2-methylpropyl)amino]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2S)-2-[[3'-fluoro-4'-(1-pyrrolidinylcarbonyl)-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2S)-2-[[3',5-dichloro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2S)-2-[[5-chloro-3'-methyl-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

15 [[5-chloro-3'-methyl-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

[[3'-fluoro-4'-(1-pyrrolidinylcarbonyl)-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

(2S)-2-[[3'-methyl-4'-(1-pyrrolidinylcarbonyl)-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-

20 propanoic acid;

[[3',5-difluoro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

(2S)-2-[[3',5-difluoro-4'-(1-pyrrolidinylcarbonyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2S)-2-[[5-chloro-3'-fluoro-4'-[(2-methyl-1-pyrrolidinyl)carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

25 (2S)-2-[[5-chloro-3'-fluoro-4'-[(2S)-2-methyl-1-pyrrolidinyl]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2S)-2-[[5-chloro-3'-fluoro-4'-[(2R)-2-methyl-1-pyrrolidinyl]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2S)-2-[[4'-[(cyclopentylamino)carbonyl]-3'-fluoro-5-(trifluoromethyl)[1,1'-biphenyl]-2-

30 yl]oxy]-propanoic acid;

(2S)-2-[[3'-fluoro-4'-[(1-methylethyl)amino]carbonyl]-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;



(2*S*)-2-[[4'-[(ethylamino)carbonyl]-3'-fluoro-5-(trifluoromethyl)[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2*S*)-2-[[5-chloro-4'-[(1,1-dimethylethyl)amino]carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

5 (2*S*)-2-[[5-chloro-4'-[(cyclopentylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2*S*)-2-[[5-chloro-4'-[(cyclopropylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

10 (2*S*)-2-[[5-chloro-4'-[(1-ethylpropyl)amino]carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2*S*)-2-[[5-chloro-3'-fluoro-4'-[(methylamino)carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2*S*)-2-[[5-chloro-4'-[(1,1-dimethylethyl)amino]carbonyl]-3'-methyl[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

15 [[5-chloro-4'-[(1-ethylpropyl)amino]carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-acetic acid;

[[5-chloro-3'-fluoro-4'-[(methylamino)carbonyl][1,1'-biphenyl]-2-yl]oxy]-acetic acid;

(2*S*)-2-[[5-chloro-4'-[(ethylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

20 (2*S*)-2-[[5-chloro-4'-[(cyclobutylamino)carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2*S*)-2-[[5-chloro-4'-[(1,1-dimethylpropyl)amino]carbonyl]-3'-fluoro[1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

(2*S*)-2-[[5-chloro-3'-fluoro-4'-[(3-methylbutyl)amino]carbonyl][1,1'-biphenyl]-2-yl]oxy]-propanoic acid;

25 and pharmaceutically acceptable salts thereof.

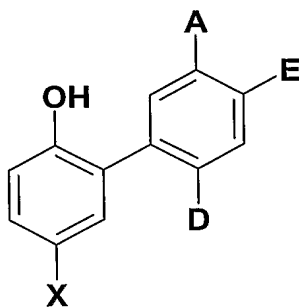
8. A compound of formula (I) according to any one of claims 1 to 7 for use in therapy.

9. A method of treating a disease mediated by prostaglandins, which comprises  
30 administering to a patient a therapeutically effective amount of a compound of formula (I), or a pharmaceutically acceptable salt as defined in claims 1 to 7.

10. A method of treating a disease mediated by prostaglandin D<sub>2</sub>, which comprises administering to a patient a therapeutically effective amount of a compound of formula (I), or a pharmaceutically acceptable salt as defined in claims 1 to 7.

5 11. A method of treating a respiratory disease, such as asthma and rhinitis, in a patient suffering from, or at risk of, said disease, which comprises administering to the patient a therapeutically effective amount of a compound of formula (I), or a pharmaceutically acceptable salt or solvate thereof, as defined in claims 1 to 7.

10 12. A compound of formula (II):



(II)

15 in which X, A, D and E are as defined in formula (I) in claim 1.

# INTERNATIONAL SEARCH REPORT

T/GB2005/003255

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> IPC 7 C07C317/22 C07D295/26 C07D295/18 C07D205/04 C07D211/16 C07D207/06 C07D261/02 C07C235/42 C07D207/10 A61K31/192 A61P11/00		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b> Minimum documentation searched (classification system followed by classification symbols) IPC 7 C07C C07D A61K A61P		
Documentation searched other than minimum documentation: to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, BEILSTEIN Data, WPI Data, CHEM ABS Data		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 99/11605 A (NOVARTIS) 11 March 1999 (1999-03-11) page 4, line 20 - page 5, line 3; claim 1	1-11
A	US 5 006 542 A (S.E. HALL, ET AL.) 9 April 1991 (1991-04-09) column 9, lines 10-17; claim 1	1-11
A	EP 1 170 594 A (PFIZER PRODUCTS) 9 January 2002 (2002-01-09) cited in the application figure 10A; example 9	1-11
-/--		
<input checked="" type="checkbox"/> Further documents are listed in the continuation of box C. <input checked="" type="checkbox"/> Patent family members are listed in annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
Date of the actual completion of the international search 26 October 2005		Date of mailing of the international search report 18/11/2005
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016		Authorized officer English, R

## INTERNATIONAL SEARCH REPORT

PCT/GB2005/003255

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	H.-J. LEHMLER, ET AL.: "Synthesis of hydroxylated PCB metabolites with the Suzuki coupling" CHEMOSPHERE, vol. 45, no. 8, December 2001 (2001-12), pages 1119-1127, XP002350952 ELSEVIER SCIENCE, OXFORD, GB ISSN: 0045-6535 compound 7a	12
P, X	WO 2004/089885 A (ASTRAZENECA) 21 October 2004 (2004-10-21) page 6; claims 1,9-11; examples 74,80	1-5,8-12

# INTERNATIONAL SEARCH REPORT

PCT/GB2005/003255

## Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:  
  
Although claims 9-11 are directed to a method of treatment of the human/animal body, the search has been carried out and based on the alleged effects of the compound/composition.
2. ☐ Claims Nos.:  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

### Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

Information on patent family members

PCT/GB2005/003255

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 9911605	A	11-03-1999	AT 237580 T	15-05-2003
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			ID 23953 A	08-06-2000
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			PL 338357 A1	23-10-2000
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			RU 2186762 C2	10-08-2002
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			TR 200000447 T2	21-07-2000
US 5006542	A	09-04-1991	NONE	
EP 1170594	A	09-01-2002	JP 2002098702 A	05-04-2002
			JP 2004004109 A	08-01-2004
WO 2004089885	A	21-10-2004	NONE	